JPRS-CEN-93-003
22 March 1993

FOREIGN
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INFORMATION
SERVICE

JPRS Report

Science & Technology

CHINA: Energy

19981214 123

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NATIONAL TECHNICAL INFORMATION SERVICE
SPRINGFIELD, VA. 22161

Science & Technology
China: Energy

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Nation To Make Major Investment To Promote Electric Power Projects

936B0044C Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 9 Jan 93 p 1

[Article by Qin Jingwu [4440 0079 0582]]

[Text] Beijing, 8 Jan—This year the Chinese electric power industry will invest large sums to further strengthen the foundation for construction of facilities to furnish support for the rapid development of the national economy.

The Chinese electric power industry in recent years has made impressive gains. Last year, large- and middle-sized generating units totalling more than 12,200MW have gone into operation, and the total national power output was up to 742 million MW. The China electric power industry has now reached the age of large units, large power plants, large grids, high voltage and high automation, and by the end of last year, single unit thermal generators of 200MW or more made up 42 percent of the total installed thermal power capacity of the country, and the largest single units are up to 600MW. There are 25 power plants with installed capacity in excess of 1,000 MW, and four trans-provincial power transmission networks of over 20,000MW, with various main networks being the first composed of 500 kV and 330 kV trunk carriers.

In 1992, China's first 300MW nuclear power unit joined the grid and began producing electricity, and commercialized prototype items have begun appearing rapidly; and with exports to Pakistan China has become one of the few nations in the world with the capability to export nuclear technology and facilities.

Since 1984 the China electric power industry has opened up multi-source, multi-layer, and multi-form investments for electricity. Chinese investments and bank loans, which were 91 percent in 1980, dropped down to 30 percent in 1992. Local investments are now up to 40 percent, investments by the Huaneng Corporation make up 15 percent, and foreign funds are now over 10 percent.

This year electric power investment will reach 52.2 billion yuan, an increase of 50 percent over last year. There are 34 new projects amounting to 20,680MW, and it is planned that 12,050MW of generating power units will come on line; the estimated annual power output will be 800 billion kWh.

Inner Mongolian Power Industry Registers Impressive Gains

936B0044A Beijing RENMIN RIBAO in Chinese 16 Dec 92 p 2

[Article by Liu Anqi [0491 1344 3825] and Li Kexin [2621 0344 0207]]

[Text] The reform has reached its 14th year, and the Inner Mongolia electric power industry has grown beyond expectations. In August 1992, the Sonid Banner and County, the last of the Autonomous Region to be electrified, turned on the lights, and a host of agricultural and pastoral peoples ended their history of dependence on oil lamps for lighting.

Inner Mongolia is vast and sparsely settled, and electrification has been retarded because of limited financial support capability and high line loss problems. Before the Seventh 5-Year Plan, 24 of the Region's 88 towns, banners, and counties were without power. During the Seventh 5-Year Plan, many ways were found to raise funds for electrification at the local agricultural and pastoral people's level. In 1985 the Inner Mongolia Electric Power Administrative Bureau tried out two avenues for raising construction funds for each kWh of rural electrification projects for some of the larger banners and counties; this was used for capital construction and line reconstruction. The Autonomous Region Government quickly applied the experience of that successful effort throughout the Region, and investment for rural electricity went from the 7 million yuan annual outlay of the past, up to 50 to 60 million yuan. In 1990, investment passed a basic figure of 90 million yuan, and in a brief 7 or 8 years the Region's rural power lines went from 40,000 kilometers in the Seventh 5-Year Plan to the present 80,000 kilometers. The volume of rural electricity increased from 560 million kWh in 1979 to over 3 billion kWh by 1992. There were 176 transformer stations in the agricultural and pastoral areas in 1979, and now there are 400. Electric power became the "Conductor and go between" for invigorating local economies; and village and town enterprises sprang up like bamboo shoots after a rain, using power to develop irrigation, mining, industry, and the rich natural resources; and put the agricultural and pastoral economies on the road to a socialist market economy.

Sichuan Electric Power: Development to Fight Shortages

936B0046A Chengdu SICHUAN RIBAO in Chinese 25 Dec 92 p 2

[Article by reporters L Daobin [0712 6670 2430] and Xia Guangping [1114 0342 1627]]

[Text] Electric power has lately become Sichuan's most sought after product. Because of power outages factory operations are curtailed, and many citizens often "grope about in the dark". People wonder, if production of electricity is always increasing, where is it going? Looking into this question, a visit was made the other day to the "power boss" - Sichuan Electric Power Industry Bureau Chief, Shi Wanjian [4258 8001 0313], and he was asked to talk about the Sichuan electric power situation, and his thoughts about how to get out of this predicament.

Shi Wanjian sees the present causes for the power shortage trend as due to the large imbalance between the Sichuan power network and the hydropower stations, where many of the power stations depend on run off and do not have regulating reservoir capacity, so that during droughts such as the present one, there is little water coming down and the main power stations have no water for generating power. At times when there is serious supply and demand disparity, thermal power plants in recent years have been operating 6,000 hours or more, and that is unthinkable outside of China! Thermal power plants cannot hold up under non-stop operations; defects increase sharply, and temporary maintenance increases. Add to that the technical reconstruction of the old Chongqing and Baima power plants where they have shut down and dismantled 12 12MW units and two 25MW units, which has caused a reduction of peak load adjustment capability, and reduced power output.

Shi Wanjian said the total provincial industrial output has had more than a two-digit increase this year, and small town industries and tertiary industries are up over 50 percent compared with the same period last year. Although the installed capacity of Sichuan power stations grew up to 1400MW last year and this year, which was the highest period of new operating installed capacity, the annual average increase was only about 8 percent, far short of what is needed for the new economic growth. At the same time, the domestic use of electricity grows daily; during the long winter days there is a high consumption of energy, high power heaters are running in thousands of homes, and daily consumption is up to over 600,000 kWh, about the output of a large-size power plant. During power shortages, the principle is to take care of electricity requirements for urban and rural livelihood, agriculture and important raw and processed materials production. But, because some urban residential lighting circuits are also used by industry and mining "partners", when power restrictions are placed on those enterprises some of the populace then must also "grope in the dark"; and the electric power department can only hope the populace will understand and be cooperative.

Shi Wanjian is apprehensive about the present state of Sichuan electric power. In 1991 the installed capacity in the whole province was 8690MW, generating 38 billion kWh per year, a per capita volume of only .08 kW, and average consumption was 341 kWh, almost down to one-half that of the national average, or only at the national average level of the early 1980s. That is to say, Sichuan's electric power output lags behind the national average by nearly 10 years, and from the standpoint of Sichuan's actual needs with the economy growing at 6 percent, by the year 2000 Sichuan's minimum requirement will be 18,000MW of operating installed capacity, which the 6 million kW installed capacity now under construction will be short of reaching by over 3 million kW. Estimating from the actual average economic growth rate in Sichuan as it is now, by the end of the century Sichuan's installed capacity shortfall will be up to 5000 to 8000MW! More specifically, the day that construction of the Ertan hydropower station is completed will not be the day that the electric power shortage is solved. There will still be an electric power "bottle neck" restricting the economic development of Sichuan.

As to how to speed up development of electric power, Shi Wanjian said that there must first be a well managed power supply enterprise, the level of power plant output must be raised, normal operations of generating facilities must be guaranteed, and there must be adequate and stable supply from multiple sources. Then, engineering and construction must be done correctly. The Huangjuezhuang power plant went into operations and began generating after 22 months, which was an all-out effort surpassing the national average for advanced-level power station construction. The renovation of the Chongqing and Baima power plants with two 200MW kW units, "replacing small with large", were completed and went into operations, on time, in the Eighth 5-Year Plan. Third, there must be guarantees that electric power capital construction will keep ahead of the people's economic development. At the same time that early stage work is being stepped up on reserve power source points, work must begin on the Baohugou (3,300MW) and the Yele (220MW) hydropower stations as quickly as possible in the Eighth 5-Year Plan, there must be more regulating reservoirs and peak-load adjustment capability must be raised. While waiting for the Ertan power station to become operational in 1998, a line of medium-scale hydropower stations requiring short construction periods, and faster development of the Nanya He and Baoxing He cascades should be considered. To supplement sharp power shortfalls during droughts there must be moderate development of thermal power; the expansion of the Huangjuezhuang plant and the second-phase construction of Luohuang power plant should get proper attention; construction of the Guangan and Chuannan thermal power plants should be scheduled and gotten underway, and work on the Baoji, Ningxia to Sichuan power transmission work should be properly handled. Fourth, as conversion of the management mechanism unfolds, investment capability should be increased to make the Sichuan Electric Power Bureau into a genuine principal investor. Bonds should be circulated, there should be worker's internal share holdings, stocks, bank loans, and foreign investments, large-scale joint ventures, electric power management agreements, funds should be raised for construction, and joint-stock power stations should be built. Sichuan now has signed electric power management agreements with the Hong Kong Huarun and Beifang Corporations, the China Wufeng Steel Tubing Co. and Dongfang Electric Machinery Factory, and has formed a pattern of multi-source, multi-level, and multi-form fund raising schemes for managing electricity.

Shi Wanjian emphasized the need to constantly increase a consciousness of opening up, improving the investment environment, raising self-development and financing capability, and increasing capital construction

of Sichuan electric power. Then Sichuan will be able to gradually satisfy its economic and social development needs.

Ningxia Completes Annual Plan Ahead of Schedule

936B0048B Yinchuan NINGXIA RIBAO in Chinese 22 Dec 92 p 1

[Excerpts] As of 14 December Ningxia completed the annual power generation plans 17 days ahead of schedule, at a total power output of 7.1 billion kilowatt-hours, which represents a 14.32 percent growth over the previous year. This is also the first time Ningxia's annual power output has exceeded 7 billion kilowatt-hours.

This year the water level of the Huang He is relatively low and this limits hydropower output. Moreover, the new power generators recently put into operation are not running in a stable manner. These presented great difficulties in the completion of this year's annual power output plan. [passage omitted]

—Working on the stable operations of the new power generators. This involves the strengthening of personnel training in key power generation plants recently put into operation. This involves improving the technical qualities of the workers and the management skills, improving disciplines in the plants, developing various training classes and various competitions among workers. This greatly improves the workers' technical and operational skill level and the maintenance skills and level of workers. This greatly lengthens the operational cycle of the power plants. [passage omitted]

Ningxia Decides To Build Thermal Power Base

936B0048A Yinchuan NINGXIA RIBAO in Chinese 12 Dec 92 p 1

[Excerpts] The Ningxia Economic Cooperation Delegation, headed by Liu Guofan, deputy party secretary of the Autonomous Region, recently made a trip south to visit Sichuan and Hubei provinces and an agreement was reached with the two provinces to build a thermal power base in Ningxia to supply electricity to Sichuan and Hubei provinces.

The Ningxia area is rich in coal reserves and is one of the nation's energy bases. However, for a long period of time, these advantages have not been fully developed because the area's communications with the outside world greatly limits further economic development. Under the guiding spirit of the Party's XXIV National Party Congress, the autonomous region's Party Committee and local government authorities have come up with a new concept of exporting power instead of coal to neighboring provinces. This concept was developed from the strategy of a socialist market-oriented economic system. [passage omitted]

With a population of 110 million, Sichuan is a big province. At present the average power per capita is only 340 kilowatt-hours, which is only 60 percent of the national average. Power supply is tight. The province is rich in hydroelectric power resources. Viewed in the long term, the development of hydroelectric power requires a correspondingly substantial capacity in thermal power. However, it is difficult to build a relatively large thermal power plant in the province, constrained as it is by the limited coal resources and the difficulties in shipping. Hubei Province is now in a power crunch. In the province, brown-out caused by insufficient power supply occurs more than 80,000 times a year throughout the province. Moreover, the increase in demand is rising rapidly. The two provinces welcome the delegation's proposal to build large power facilities in Ningxia and export the power to distant Hubei and Sichuan via DC power transmission lines. After careful deliberation and discussion, all parties agreed that horizontal integration and the export of power from north to south conforms to the national policy on national assets and the optimization of natural resources. The three provincial authorities agreed and are willing to use dedicated power plants, to use dedicated transmission lines and dedicated supply routes to supply Sichuan and Hubei with power generated in Ningxia via express routes, based on the principle of profit sharing and risk sharing. Moreover, the relevant departments have been asked to form task forces to start working on the details of the plan.

On 19 November, the delegation also reported to comrades from the Ministry of Energy Resources, China Power Resources Company, National Energy Investment Company and Northwest Power Administration Bureau who were attending a meeting at the time in Chongqing. The leadership gave enthusiastic support to the proposal. They said that energy bases not only need to attract coal from outside but also need to export power. They added that Ningxia's move to adopt an open-minded approach and to export power to markets outside its territory is a step in the right direction. Exporting power instead of transporting coal is the inevitable route for Ningxia's massive economic development. Regarding capital, this can be raised domestically as well as externally by actively attracting foreign capital. [passage omitted]

Shaanxi Puts 1000MW Into Operation in 1992

9360047A Xian SHAANXI RIBAO in Chinese 29 Dec 92 p 1

[Article by reporter He Tao [6320 7290]]

[Text] This year has been a bonanza for Shaanxi electric power as over 1000MW of installed generating capacity went into operation, the largest amount of new operating capacity on record. On 28 December, the Northwest Electric Power Administrative Bureau held a celebration meeting at the Wei He power plant. Provincial leaders Zhang Boxing, Zhou Yaguang, Xu Shanlin, Liu Chunmao, Zhang Bin, Zhang Xu and authorities of pertinent departments attended the celebration meeting.

When the two 300MW units of the Wei He power plant's second-phase expansion project, a key national construction project, the last two 200MW units at the Ankang hydropower station, and a series of locally built small thermal power units went into operation, they put the new operating installed capacity in Shaanxi up over 1000MW in a single year; up to 1080MW or 30 percent of that installed since Reconstruction, and equal to that of the Sixth and Seventh 5-Year Plans together. Not only will it lift Shaanxi single-unit generating capacity up over the 300MW mark for the first time, it demonstrates a major step forward toward a high-parameter modernized standard of electric power facilities for Shaanxi.

Liu Chunmao, representing the Provincial Committee and Provincial Government at the celebration meeting, expressed his heartfelt gratitude and fond hopes before the gathering of electric power builders who sent forth the engineering plans, did the manufacturing, construction, engineering, testing, operating, supplying of materials, and back up services for the Wei He power plant and Ankang hydropower station.

Lubuge Passes State Formal Acceptance, Operating Smoothly

9360043C Kunming YUNNAN RIBAO in Chinese 12 Dec 92 p 1

[Article by reporters Lu Jianhua [7120 1696 5478] and Liu Liu [0491 3177]]

[Text] The Lubuge hydropower station project, Yunnan's "window" to the outside and testing ground for management system reform, after 18 months of operations since the last unit joined the grid on 14 June 1991, passed formal state examination and acceptance on 11 December 1992.

The State Examination and Acceptance Committee, after inspecting the whole project, judged the Lubuge project fully completed in accordance with state approved design documents. The project design is reasonably advanced, of excellent engineering quality, its construction progressed normally, the station exemplifies its design, the project is still within budget estimates, and the committee has agreed to approve the project and formally turn it over to control of the operating unit.

The State Examination and Acceptance Committee also considers the Lubuge hydropower station a pilot project for national hydropower construction management system reform, and outward reaching construction. Its mission as a testing ground was well accomplished also, setting an example for a swift, fine quality, low cost hydropower project, and providing valuable experience for consruction of large-scale hydropower stations.

At 2:30 P.M. on 10 December, a commemorative marker erected in front of the main building of the hydropower station praising the reform policy and honoring the exploits of the builders was formally unveiled. On the marker, six large characters styled by Premier Li Peng's own hand, read, "Lubuge Hydropower Station."

Lubuge is located on the Huangni He at the boundary of Luoping County, Yunnan, and Xingyi, Guizhou. The station has four 150MW units. The project presents a magnificent spectacle of massive engineering. The budget estimate for the project was 1.66 billion yuan, of which foreign funds made up 489.120 million yuan, or 29.45 percent of the budget estimate.

The Lubuge hydropower station was the first to use a World Bank loan and complimentary funds from foreign governments for its construction, and the first to employ international competitive bidding for the civil engineering. The collision of the old and new system and points of view over the project sent a "Lubuge shockwave" that reverberated around the country.

The newly formed project management organization set up according to the general format of construction management reform and requirements of the World Bank, the Lubuge Project Administrative Bureau, learned through practice, gained experience in modern project management, and became the guiding force for the engineering and construction. The Kunming Hydropower Survey and Design Academy, which undertook the survey and design mission for the hydropower station, assisted by the Special Advisory Team, and the Norwegian and Australian advisory units, and carefully regarding the opinions of the construction and engineering units, made steady improvements in the project design, and saved 46 million yuan of the investments. The Design Academy's "Lubuge Project Geological Investigations" and "Lubuge Hydropower Station Project Design", earned a national award [6855 6347 1162]; for excellent investigations and national award for excellent design. The 14th Hydropower Bureau, which handled the overall construction preparations and the construction of the head building and underground plant, was creatively reform minded and produced an excellent level of quality engineering. The Japanese Taisei Company, which won the contract for construction of the intake system, completed the project on schedule. There were eight construction units involved in the project, and with the exception of one which performed satisfactorily, the others achieved an outstanding 87.5 percent excellency rating, and the overall project was rated as excellent. Fourteen national construction records were set, and one of those was a new world record.

The installed capacity of Lubuge is about one-fourth that of the whole Yunnan network, and during high water periods it will carry over 40 percent of the full load of the whole provincial network, and will play a pivotal role in the operations of the entire network. From the end of 1988 when the first unit went into operation, to the end of October of this year, the station's cumulative output was 7.89 billion kWh, which has been a great boost to Yunnan's economic development.

The State Examination and Acceptance Committee is made up of leaders and specialists of the pertinent departments of the State Planning Commission, Ministry of Energy Resources, National Energy Investment Corporation, and Yunnan and Guizhou. The Vice Minister of the Ministry of Energy Resources, Lu Youmei, was Chairman of the Examination and Acceptance Committee, and Vice Governor of Yunnan, Li Shuji, and Secretary General of the Guizhou Provincial Government, Xie Yanghui, were Vice Chairmen.

At the examination and acceptance signing ceremony on 11 December, The Ministry of Energy Resources presented souvenir mugs to the World Bank Advisory Team which had made a special trip to attend the event, the Norwegian and Australian Advisory Unit representatives, and a "Certificate for Outstanding Engineering" to the Japanese Taisei Company for the intake system engineering, and gave them a souvenir mug as well.

Fourth Unit at Ankang Now Operational

936B0046B Xian SHAANXI RIBAO in Chinese 25 Dec 92 p 1

[Article by reporters Dang Chaohui [7825 2600 2547] and Sun Wei [1327 1550]]]

[Text] The last 200MW unit of the Ankang hydropower station, a key national engineering project undertaken by the Third Hydropower Bureau, joined the grid and began generating electricity ahead of schedule on 24 December. Four units are now in operations, concluding satisfactorily the installation project.

The Ankang hydropower station, the backbone project of Shaanxi's electric power system, built primarily for power generation, will also serve navigation, flood prevention, cultivation, and recreational uses. The installed capacity of the power station is 800MW, and its annual output will be 2.8 billion kWh, or the equivalent of 1.7 million tons of standard coal for power generation. Not only will it relieve the power shortage in Shaanxi, but it will also raise the peak load capability of the northwest power network, power regulating capability, and supply a back up reserve for accidents and disasters. It completes the Shaanxi north-south hydro-thermal reciprocal distribution among the various bureaus of the electric power industry, and will have an important impact on the economic development of the whole province.

National investment for the project was 2.4 billion yuan. Working hard on this project for 14 years, the Third Hydropower Bureau overcame complex geological conditions, frequent floods and other difficulties, and from the pouring of the dam to installing the machinery, they employed scientific management, strict requirements, and guaranteed quality engineering. A line of new technology and procedures were employed to solve the major technical problems of "stabilizing high slopes to prevent slides, a slightly inclined dam foundation, a torrential flood discharge capability"; and achieved a technologically revolutionary Chinese revolving diametric welding process [6567 6544 4160 2234 1417 6919] on their first attempt. It has earned the recognition of the State Council and Ministry of Energy Resources leadership who have designated it a "National Meritorious Construction Unit", and it has made a positive contribution to hydropower construction.

The Ankang hydropower station is located on the upper Han Jiang at the Huangjin water course. Since the first unit went on line, the superiority of hydropower is daily evident; the water resources are cheap and inexhaustible, have none of the social effects of polluting, and still other all round benefits. After a one-time investment there is no need for further investments. Its completion signals the beginning of the opening up of the Han Jiang for Shaanxi.

The Shaanxi Government extended special invitations to consultant Zhang Bindeng and other authorities of pertinent departments to celebrate the ribbon cutting for the power station.

Lijiaxia, Dashankou Update

9360043B Kunming YUNNAN RIBAO in Chinese 27 Dec 92 p 1

[Article by reporters Jin Jiasheng [6855 0857 5116] and Dang Zhou [7825 0719]]

[Text] Xining, 26 December (XINHUA)—On 24 December, a contract on a bid to manufacture five water turbine generators for the Lijiaxia hydropower station, the largest on the upper reaches of the Huang He, was formally signed. At this point, the "systems engineering" for the hydropower construction is fully underway.

The Lijiaxia hydropower station will follow the construction of the Longyangxia hydropower station, another large-scale hydropower station being built on the upper Huang He. It is a key national project of the Eighth 5-Year Plan, and will be built with investments from the state and four provinces—Qinghai, Gansu, Shaanxi, and Ningxia. The total installed capacity of the station will be 2,000MW, with five units of 400MW capacity each, the largest unit capacity of any hydropower station now under construction in China. The Dongfang Electric Machinery Factory at Deyang, Sichuan won the bid to build all of the units.

RENMIN RIBAO, 27 December, reporter Wang Xuelin [3768 1331 2551]—At the Dashankou hydropower station, the largest hydropower project in the Xinjiang Uygur Autonomous Region to date, the last water turbine generating unit completed its 72-hour test run, and will formally join the grid on 21 December. Premier Li Peng expressed his "enthusiastic congratulations for the completion and start up of the Dashankou hydropower station."

The Dashankou hydropower station, listed as a key project in the Seventh 5-Year Plan, and located in Hejing County on the Kaidu He on the south slope of Tian Shan, is a multi-purpose water conservancy project for generating electricity and flood prevention. The total investment for this station was over 200 million yuan. Its total installed capacity is 80MW, and its annual output will be 300 million kWh.

Tianshengqiao, Wan'an, Panjiakou Update

9360043A Beijing RENMIN RIBAO in Chinese 24 Dec 92 p 1

[Article by Chen Yanxu [7115 1693 4872] and Tang Liliang [3282 2621 2733]]

[Text] The Hydropower Command of the Chinese People's Armed Police Force has recently reported on five generating units at three hydropower stations, Tianshengqiao in Guangxi, Wan'an in Jiangxi, and Panjiakou in Hebei, which collectively have a total capacity of 600MW, have each completed 72 hours of combined testing, and have gone into operation, completing their state assigned missions ahead of schedule. The five units have an average annual electric power output of 2 billion

kWh, and make up 30 percent of this year's national plan to put large and middle-sized hydropower stations into operation.

The Tianshengqiao second-cascade hydropower station, backbone of the water conservancy and resources project for opening up the Hongshui He watershed, has a total installed capacity of 1,320MW, and an annual output of 8.2 billion kWh. Its completion will have an important impact on relieving electric power consumption pressures in the south and southwest. It is also the largest underground intake tunnel engineering project of all similar type hydropower stations in China, and has the longest tunnel of any hydropower station of 1,000MW or more installed capacity, with very difficult geological conditions and engineering complexity. The first unit of this station joined the grid and began operations in 19 December, and on 22 December, the State Council expressed its enthusiastic congratulations by cable to the First Hydropower Brigade which undertook this project.

The Wan'an hydropower station, the largest river-bed type station in Jiangxi, has four units with a total installed capacity of 400MW. The officers and men of the Second Hydropower Brigade, having installed two units ahead of schedule—despite two floods in March and July, a once-in-a-century occurrence—fulfilled their mission to install and put into operation two 100MW units.

The Panjiakou hydropower station, now China's largest pumped-storage station, has three units with a total capacity of 270MW, and will serve as a load regulator during base and peak load periods, and as a distribution interchange for service continuity, and back-up during emergencies.

The First Hydropower Detachment, Fifth Hydropower Bureau installation office, and Tianjin Design Academy working together, smoothly completed their mission and put two units into operation, one in September and one in December.

Oil Industry Meets Goals Early

936B0047B Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 30 Dec 92 p 2

[Article by reporter Li Gang 2621 6921]]

[Text] Beijing, 29 Dec—The China Petroleum and Natural Gas Corporation has proclaimed the implementation of the CPC and State Council policy of "Stabilize in the east, develop in the west" to be a brilliant success as this year's national production plan has been fulfilled ahead of schedule with crude oil production breaking 140 million metric tons, and natural gas output at 15 billion cubic meters.

Corporation authorities say the distinguishing feature of production and construction in the petroleum industry this year has been the level of oil and gas field development and parallel production levels are both clearly higher. The technical measures implemented by Daqing oil field to "stabilize oil and control water" has resulted in an output of 55.65 million tons for the year, an overage of 250,000 tons, sustaining the 17-year output level of over 50 million tons per year. Shengli, Liaohe, and other oil fields have all completed their annual plans over quota.

The west was the key to this years' increased national production of crude oil. While prospecting was being increased, reserves were being added, and a number of new oil fields were coming under construction in the Tarim, Turpan-Hami, and Junggar Basins in Xinjiang; crude oil output continued to increase on a broad scale. With other western oil fields included, the production of crude oil for the year was 12.6 million tons, more than 1.2 million tons over the previous year, demonstrating that the west has genuinely taken over as the national petroleum resource and production growth area.

Natural gas prospecting and development continue to make great strides. New proven reserves this year are over twice the plan; this not only creates the highest levels in history, but also completes the new natural gas reserves plan for the Eighth 5-Year Plan 3 years ahead of schedule. With national level approval, development of the northern Shaanxi natural gas field will formally begin, and the long distance gas line to Beijing, Xian, and Yinchuan will be built. Preparations are also being made to ship natural gas from Turpan-Hami to Urumqi, and from Qinghai to Xining, Lanzhou, which will gradually improve the fuel structure of those cities.

Big Oil Field Found in Tarim

9360044B Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 14 Jan 93 p 1

[Text] Beijing, 13 Jan—The Tarim Oil Field Prospecting and Development Directorate has just announced that a major oil field ready for exploitation with a reserve of over 100 million tons has been discovered in the middle of a desert in the Tarim Basin.

This oil field, located in the Tazhong No 4 anticlinal structure of the central Taklimakan Desert, has three sets of oil layers all in carboniferous strata. The total depth of the oil layers is 42 to 98 meters.

Tazhong-4 well is the discovery well of this oil field, which during tests yielded 285 cubic meters of crude oil per day and 53,000 cubic meters of natural gas. To further clarify the types and extent of oil deposits exploratory drilling was continued at the Tazhong-401 and Tazhong-402 wells, and was completed late last year. On 2 January this year, a completion well test was run on the bottom oil layer at the Tazhong-402 well using an 11.11 millimeter oil bit, which produced 589 cubic meters of oil per day and 65,000 cubic meters of natural gas; the shaft pressure was high, and output pressure varied only slightly, indicating the oil layer has very strong production capability. The Tazhong-402 well is now being tested.

The Tazhong-4 discovery has stirred up the Chinese petroleum geology circles, and experts all agree that this is the biggest Tarim oil find to date.

'Nationalization' of Nuclear Power Equipment in China

936B0030 Beijing HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 13, No 5, 10 Oct 92 pp 1-6

[Article by Zhang Minghan [1728 2494 3352] of the Ministry of Machine- Building and Electronics Industry Technical Advisory Commission, Tang Zide [3282 4793 1795] of the State Council Nuclear Power Leadership Group Office, Beijing, Chen Binmo [7115 6333 1075] of the China Power Generation Equipment Industry Association, Beijing, and Wang Jue [3769 6030] of the Ministry of Machine-Building and Electronics Industry Machinery S&T Information Department, Beijing: "Research on Shifting To Domestic Production of Nuclear Power Equipment in China"]

[Text] Abstract: Based on China's experience and actual capabilities in nuclear power plant equipment design and manufacturing, this article analyzes the necessity and possibility of a shift to domestic production of 600MW nuclear power plant equipment. The authors point out that gaining a good grasp of nuclear island equipment design is the key to shifting to domestic production. In the area of nuclear power equipment manufacture, China has a substantial foundation and with a few additional measures and filling in a small amount of key processing equipment and testing instruments, it is estimated that present requirements could be met. The authors also suggest steps and measures for shifting to domestic production of nuclear power equipment in the present stage. Finally, they provide a concrete analysis of the equipment manufacturing situation for China's first set of 600MW nuclear power generators, which they estimate overall to have a domestic production rate of about 70 percent.

Key terms: nuclear power plant, nuclear island equipment, conventional island equipment, manufacturing industry, shift to domestic production.

China's development of nuclear power must adhere to the principle of "relying mainly on ourselves, with Sino-foreign cooperation" and take the route of moving toward doing our own design and management and shifting to domestic production of equipment. Building nuclear power plants involves engineering projects that fall within the scope of high S&T and the quality requirements for equipment are especially strict. The degree of a shift toward domestic production of nuclear power equipment is related to manufacturing levels and management levels, as well as to upgrading existing enterprises. For this reason, research on policies, speed, and the portion that we can assume responsibility for in the initial stages of shifting to domestic production is very important.

I. The Nuclear Power Equipment Manufacturing Industry Is One Important Basic Structure in Developing Nuclear Power

According to information provided by IAEA experts, formulating and implementing nuclear power programs, building nuclear power plants, and ensuring their safe operation require the support of a complete set of basic structures. The basic structures are composed of many aspects. They include government, legislation, education, capital, industry, and so on. Among them, the nuclear power equipment manufacturing industry is one of the important basic structures for developing nuclear power. The supply of all machinery and electronic equipment related to nuclear power plant construction, project design, project management, operation, and maintenance services, personnel training, and so on cannot be detached from support by the nuclear power equipment manufacturing industry. Thus, if China wishes to develop nuclear power and increase the proportion of equipment that is produced domestically when building nuclear power plants, we must study the capabilities of our own nuclear power equipment manufacturing industry.

In many aspects of manufacturing technology, the nuclear power equipment manufacturing industry is similar to the thermal power equipment manufacturing industry, chemical flow process equipment manufacturing industry, petroleum equipment manufacturing industry, instruments and gauges manufacturing industry, and so on, and they are interrelated and inseparable. However, the many unique requirements of nuclear power equipment compared to regular electromechanical equipment, such as considering the effects of irradiation on materials, preventing leaks of radioactive material from equipment structures, preventing moist steam and its water corrosion characteristics, equipment quality requirements that must guarantee conformity to safety grade requirements, and so on all give nuclear equipment manufacturing different characteristics from conventional equipment manufacturing.

The nuclear power equipment manufacturing industry throughout the entire process of nuclear power plant construction is also the department that requires expending the greatest numbers of workers. Manufacturing the equipment for 1,000MW generator nuclear power equipment takes about 2 million man/hours (see Table 1). Because of differences in labor productivity, computation methods, and subcontracting methods in each country, there are substantial differences in this figure but it confirms that all require large amounts of manpower.

Implementing this 10,000-plus man/years or 2 million man/hours takes a total of 3,000 man/years of skilled technicians and technical personnel as well as advanced engineering and technical personnel and administrative personnel. These people are distributed in several 100 manufacturing plants, and the plants that manufacture nuclear power equipment must all develop to a substantial level in terms of technology, economics, personnel qualifications, and other areas.

Table 1. Work Time Required To Manufacture 1,000MW Generator Nuclear Power Equipment

	Technical personnel and administrative personnel, man/years	Technical workers, man/years	Non-technical workers, man/years	Average schedule, years
Nuclear steam supply system and nuclear auxiliary systems	1,530	3,750	1,670	5-6
Steam turbine electric power generators	250	1,170	610	4-5
BOP equipment	480	1,670	830	3-4
Electrical equipment	130	1,000	250	1-3
Gauges and control equipment	60	500	50	2-4
On-site work at the power plant	330	750	80	6-8
Overall management and technical work	670	-	-	8-10
Total	3,450	8,840	3,490	-
Overall total	15,780 man/years			

The nuclear power equipment manufacturing industry must also guarantee that the goods are delivered according to the progress in the project plan because delaying the time that power is generated can result in frightening economic losses. Thus, the manufacture of certain equipment with relatively long manufacturing schedules must begin 2 to 3 years ahead of pouring the first vat of concrete and the final group of components should also be delivered and installed prior to overall debugging of the power plant equipment. The manufacturing plants' manpower, especially advanced technical personnel and administrative personnel, should gradually be moving to their posts 8 years before a set of nuclear power generators begins commercial operation, about one-half of the manpower must begin working 5 to 7 years in advance, and nearly all of them must be involved in this work 2 to 4 years in advance. Thus, the work in all areas must be coordinated very well. Careful arrangements must start with the request made by the proprietor, the design, ordering equipment and materials, manufacturing, and so on to avoid having to work overtime and at additional sites to fight for time in the end, which can cause product quality accidents and delay construction schedules.

The nuclear power equipment manufacturing industry must understand that the prices for the equipment it supplies must be competitive compared to the corresponding prices on the international market. This basic structural capability of the nuclear power equipment manufacturing industry is the primary factor that determines the proportion a country can actually assume responsibility for shifting to domestic production to build nuclear power plants. On the other hand, to enable the nuclear power equipment manufacturing industry to truly be able to take on the tasks it is given, several questions that must be clarified: 1) The extent of shifting to domestic production by a country wishing to make its own decisions in achieving a nuclear power program. What are the initial stage and ultimate objectives? 2) The degree of stability in nuclear power programs and whether or not a decision has been made regarding the development of a single standard model. Could changes occur? 3) To establish an industry structure that conforms to requirements, can the scientific research and technical upgrading areas receive investments? How much can they receive? 4) If the technology now understood in industrial circles cannot fully meet requirements, can part of the advanced technology be imported? In summary, the degree to which a country's manufacturing industry should participate in plans for a shift to domestic production of nuclear power is determined by the optimum economy and independent decision making in shifting to domestic production, which is a political objective. This is also the motive force for a country's industry to participate in nuclear power construction.

II. The Necessity of Shifting to Domestic Production of Nuclear Power Equipment

A. The relationship between domestic production of nuclear power equipment and total investments in a power plant

Nuclear power plants involve huge investments, so when developing nations develop nuclear power the problem is often not only capital problems but the even greater difficulty in making the foreign exchange outlays. Therefore, achieving a shift to domestic production is one of the keys to the success or failure of China's nuclear power industry. The direct expenditures for nuclear power plants generally include three parts: project design and management, civil engineering, installation, and debugging, and equipment design and manufacturing. Among them, nuclear power equipment expenditures account for a very large portion of the total investment in nuclear power plant construction. According to the

IAEA and data on different projects provided by various countries, equipment expenditures account for about 55 percent.

Thus, to reduce the total investment in nuclear power plants, consideration must first be given to reducing equipment expenditures. Undoubtedly, the way to reduce equipment expenditures is shifting to domestic production of nuclear power equipment. The relevant data show that if we import a full set of equipment and materials, equipment costs would account for 78 percent of the total investment, whereas the proportion when using equipment for similar types of domestic generators would be 42 to 45 percent of the total investment, while the investment in installation projects would be about 10 percent of the total investment. One can see that importing complete sets of equipment as a proportion of the total investment would be 33 to 36 percent higher than similar types of domestic generators. If installation expenditure indices are added in making the comparison, the relative difference would be 27 to 30 percent. Practice also has proven that the manufacturing costs of imported generators are too high. In summary, a shift to domestic equipment production will inevitably reduce the total construction costs for power plants.

B. The relationship between shifting to domestic production of nuclear power equipment and preparing our own designs

Preparing our own nuclear power designs is the first link in developing nuclear power. It includes project design, purchasing, and tracking and it is mutually complementary with shifting to domestic production of equipment. Without domestic production of the equipment, a project design must seek equipment from foreign countries. In contrast, if we do not make our own decisions regarding project designs and allow foreign businesses to make the overall arrangements and select the equipment to use, this would certainly make the conditions for shifting to domestic production of equipment extremely harsh. Thus, only by making our own design decisions will there be full scope for our abilities. In contrast, we can only truly make our own design decisions and attain our economic and safety objectives by achieving a shift to domestic production of nuclear power equipment. It could also be said that only with domestic equipment production will making our own design decisions have reliable reserve strengths.

C. All countries of the world are concerned about shifting to domestic production of nuclear power equipment

The history of nuclear power development over the past 30-plus years shows that France, Germany, Japan, and other industrially developed nations all imported advanced technology from foreign countries when they began developing nuclear power but afterwards they based themselves on doing their own equipment manufacture in their own country. Now, all of them have established their own national manufacturing industry systems on a large scale. During the process of nuclear power construction, several developing countries and regions like India, Spain, South Korea, Brazil, Argentina, and so on have all tried to have industrial departments in their own country assume responsibility for design, manufacturing, and technical services and promoted to a maximum degree a shift to domestic equipment production. The nuclear technology transfer report prepared by the Westinghouse Corporation in the United States in March 1985 shows that there were 158 contracts/year for nuclear power plant equipment technology transfers while the technology transfers in the NSSS system were only 82 contracts/year, indicating that all countries are very concerned about importing equipment manufacturing technology.

D. Shifting to domestic production of nuclear power equipment will raise industrial technology levels

The manufacturing technology for nuclear power plant equipment such as reactors, steam turbines, and so on is all of a highly technology-intensive type. Gaining an understanding of the design technology and manufacturing technology for this type of equipment will spur continued development of China's nuclear power industry and promote improvements in China's industrial technology levels, quality levels, and management levels.

III. Analysis of the Conditions for Shifting to Domestic Production of Nuclear Power Equipment in China

A. The current situation in nuclear island equipment design

Since the 1960's, for various reasons the design of nuclear reactor equipment in China has been the responsibility of several different units and there have been several different forms of a division of labor. One is joint design organized by engineering and design academies and manufacturing departments. A second is engineering and design academies assuming responsibility from the technical design to the construction blueprint design while manufacturing plants do the construction according to the blueprints after examining the technology. The primary equipment for the nuclear island at Qinshan Nuclear Power Plant is an example. A third arrangement is engineering and design academies providing technical standards documents that are turned over to plants, which are responsible for all of the design work. Examples of this include several general-purpose pumps, valves, vessels, instruments and gauges, electric motors, electrical systems, etc. Because of the rather large number of forms of division of labor for equipment design, the accumulated information is very scattered and is neither coherent nor systematic. China also lacks experience in large-scale equipment design for 600MW nuclear power plants. Of course, equipment that has already been in trial manufacture or that is in operation can be selected for some of this equipment, but since the

parameters are different several improvements may be necessary. Overall, we have no set of existing equipment design blueprints and data for the primary equipment for a nuclear island that can be supplied to plants for their use in production. The situation during the first phase project at Qinshan Nuclear Power Plant indicates that we could design a large portion of the primary equipment ourselves. We could also do our own designs for a large portion of the auxiliary equipment, including various types of tanks, vessels, heat exchangers, water treatment equipment, and equipment in the pump and valve category. We may have to import the technology or have Sino-foreign cooperation for some of the special-purpose primary equipment to satisfy requirements. The reason is that much experimental research must be done prior to designing this special-purpose equipment to obtain the necessary design data before overall designs for the units can be prepared. After the trial manufacture of prototypes, we must also conduct comprehensive tests of performance and structures on full working conditions experiment consoles. However, full working conditions experiment consoles require huge investments, so we fear that this cannot be achieved for the time being. Moreover, China's nuclear power tasks prior to the year 2000 are limited, so spending this huge investment would also be uneconomical. Thus, when the conditions permit, taking the route of importing technology and Sino-foreign cooperation and having foreign businesses supply mature design blueprints could help manufacturing plants supply products that meet specifications.

In another area, China still does not have a complete system of standards for nuclear power plant construction, which increases the difficulty of equipment design and manufacture. We must adopt measures to organize forces in the related areas to adapt to the safety and quality requirements of 600MW nuclear power plants.

B. The current situation in conventional island equipment design

Manufacturing plants have primary responsibility for designing conventional island equipment, all the way from thermal power plants to 300MW nuclear power plants. The relevant plants in China have basically formed a powerful equipment design staff that has accumulated relatively abundant information. They also have the support of equipment research institutes and institutions of higher education, whose design forces are relatively powerful. Generally speaking, they can assume responsibility for designing conventional island equipment for nuclear power plants. For example, the Harbin Steam Turbine Plant, Dongfang Steam Turbine Plant, and Shanghai Steam Turbine plant are all capable of designing 600MW nuclear power turbines and they have each already provided design programs.

Nuclear power plant generators are no different in structure from thermal power plant generators. For example, if we adopt full-speed generators, we can select existing mature electric power generators. The generators at Qinshan Nuclear Power Plant utilize 300MW dual-loop internal water cooled generators that were designed by China itself. Shanghai and Harbin Generator Plants jointly designed and built 600MW thermal power generators with an optimized design that passed inspection at a design inspection meeting jointly convened by the former Ministry of Machine Building and Ministry of Water Resources and Electric Power, and they may be recommended for use at 600MW nuclear power plants.

Shanghai Steam Turbine Plant already has the design and manufacturing technology for steam-water separation reheaters that can be used as a basis for designing the overall units, components, and each of the systems.

Condensers in the past have consistently been based on domestic design and production. The condensers for the 300MW and 600MW thermal power generators were designed by the Shanghai Steam Turbine Plant, Dongfang Steam Turbine Plant, Harbin Steam Turbine Plant, and Shanghai Power Plant Auxiliary Equipment Plant themselves. They were produced by the Shanghai Power Plant Auxiliary Equipment Plant, Dongfang Steam Turbine Plant, and Harbin Steam Turbine Plant and are now in operation at power plants. The condensers used in the 300MW generators at Qinshan Nuclear Power Plant were designed by Harbin's Institute 703 and manufactured by the Shanghai Power Plant Auxiliary Equipment Plant, and they have been delivered to Qinshan Nuclear Power Plant for installation. The condensers for the 600MW super-critical generators at Shidongkou No 2 Power Plant were produced by the Shanghai Power Plant Auxiliary Equipment Plant. Thus, the condensers for 600MW generators at nuclear power plants can be based on domestic designs.

Shanghai Power Plant Auxiliary Equipment Plant designed and manufactured the high-pressure heaters used for 300MW and 600MW generators, and their operation conditions are excellent. They have now designed and manufactured the high- pressure heaters used for the 300MW nuclear power generators. Thus, this data can be used for our own designs for 600MW nuclear power high-pressure heaters.

An analysis of the above discussion shows that China has all of the conditions required to design our own 600MW nuclear power conventional island equipment. Of course, imports of technologies and consulting with foreign countries may be required for certain types of equipment.

C. Analysis of manufacturing technology and equipment conditions

Overall, macro analysis of China's conditions for manufacturing nuclear power equipment shows that they are relatively good. The basis for this is the following points:

1. Starting in the 1960's, China relied on its own efforts to develop complete sets of nuclear power pressurized water reactor [PWR] and graphite water-cooled reactor equipment, and over 150 primary plants in China were involved in the production of nuclear equipment. They gained an understanding of many of the key technologies for manufacturing small PWRs, such as high-strength low-alloy steel smelting and forging, buttering, precision processing, and heat treatment of the interior walls of reactor pressure vessels, manufacturing the seals of main pumps and saturated steam generators, and so on, and trained a technical staff.

2. Starting in the late 1970's, we began manufacturing 300MW nuclear power equipment, upgraded several plants, established new heavy vessel workshops and steam turbine workshops, added large-scale processing equipment, built product testing consoles, and so on, which strengthened our manufacturing capabilities and technical levels for nuclear power equipment. Shanghai Boiler Plant, for example, used development of steam generators and pressure stabilizers to gain an understanding of several key technologies and used them in production practice. Examples include thick wall main welding seam welding technology, large-area interior wall stainless steel and nickel-based alloy buttering technology, tube and tubesheet expansion and connection technology, deep hole processing technology, far infrared heat treatment technology, and so on. The 300MW nuclear power steam turbine generators were also successfully manufactured on a trial basis. A quality assurance system was also completed in the management area.

3. China's implementation of a policy of opening up has accelerated technology imports and technical upgrading in old enterprises. An example is the importation and digestion of 300MW and 600MW thermal power steam turbine generators and 500 kV power transmission and transformation equipment manufacturing technology. We have also upgraded manufacturing conditions in power generator equipment manufacturing plants and added large-scale precision processing equipment, which has raised domestic production levels of equipment.

In summary, we already have a substantial foundation of manufacturing conditions for nuclear island and conventional island equipment and with a few additional measures, especially the addition of a small amount of key equipment and key measurement instruments and experiment consoles, we estimate that current requirements could be met. If we move into batch production in the future, this would require further measures to expand our production capabilities.

IV. The Steps in Shifting to Domestic Production of Nuclear Power Equipment

Based on actual conditions in China, our proposals for shifting to domestic production of nuclear power equipment and the steps to be taken are:

1. Work on the easy things first and the hard things later. All products where domestic industry has gained a grasp of the technology should lead the way in shifting to domestic production. We should make appropriate arrangements for a small number of more difficult technologies which we must gain an understanding of during the initial stages, for which we have a rather good domestic technical foundation and can use scientific research to attack key problems to do the work well, and key equipment for which plants do not have to adopt upgrading measures or very few upgrading measures. This will spur improvement in levels of domestic production of nuclear power equipment.

2. Give consideration first to products needed in large numbers and covering broad areas that can also be extended into non-nuclear departments. Give consideration later to products needed only in small numbers with narrow markets and high costs, and which would be uneconomical for the time being to shift to domestic production.

3. For products that are closely related to safety and for which we have not gained an extremely good understanding of domestic production, there must be careful analysis when shifting to domestic production to avoid any mistakes.

4. In the area of complete sets of products, we do not have to pursue 100 percent domestic production. For specific single products, we do not have to pursue domestic production of every component or material. We should seek truth from facts. As for the rate of domestic production of large-scale nuclear equipment, the proportion can be somewhat lower for the first set and we can gradually increase it later in an effort to achieve an 80 to 90 percent domestic production rate by the fourth set.

Based on the above views concerning a sequence for shifting to domestic production of nuclear power equipment and on China's equipment production conditions, we feel that the following types of products for the first set of 600MW nuclear power equipment can be based on domestic sources:

1. Among the special-purpose equipment, the pressure vessels, steam generators, in-reactor assemblies, pressure stabilizers, control rod drive mechanisms, and so on. This type of equipment is a comprehensive embodiment of various unique technologies and has relatively high technical requirements. China has already basically gained a grasp of the manufacturing technology and our manufacturing conditions are also relatively good.

2. Various types of container equipment, including all sorts of heat exchangers, filters, desalinators, separators, tank, vats, etc. This type of equipment is required in large numbers and covers broad areas, and can also be used in non-nuclear departments. Many plants in China are capable of producing this type of equipment and we can solicit bids to select the best for purchases.

3. All types of pumps and valves. With the exception of the main pumps, nuclear second-level pumps, water

circulation pumps, feedwater pumps, condensed water pumps, safety valves, main steam isolation valves, and other things that will require Sino-foreign cooperation, the other general-purpose pumps and valves are required in large numbers and cover broad areas, and can also be used in non- nuclear products. Their manufacturing industry basically involves casting or forging, mechanical processing, and so on, and most of the water pump plants and valve plants in China are capable of manufacturing them. We can also solicit bids to purchase them.

4. Manufacturing steam turbine electric power generators, diesel electric power generators, and other equipment requiring precision processing requires precision processing equipment with relatively high precision requirements. China's power generation equipment plants and motive power machinery plants all have the conditions to manufacture this type of equipment. We can also solicit bids for fixed-site production.

5. We basically can make production arrangements within China for the piping (with the exception of the main piping), pipe support components, ventilation equipment, hoisting equipment, and other such equipment.

6. With the exception of some individual items, our domestic production conditions for all types of electric motors and electrical equipment can satisfy requirements, but we must fix sites to select the best for purchases.

7. Main control equipment involves many product varieties and great numbers. Because the design programs have not yet been completed, it is hard to do concrete analysis. China's instrument production industry has a substantial production capability and conditions for the automatic control systems and instruments in the conventional island and can produce them, but some components will have to be imported from foreign countries to ensure their quality.

V. The Rate of Domestic Production of Nuclear Power Equipment

Estimates based on our preliminary understanding indicate that there are different domestic production rates for different equipment. All of the estimates were made based on prices. Because the equipment design blueprints and technical requirements are not yet clear, and because the equipment order contracts cannot be signed yet, there may be substantial changes in the actual prices. Thus, the results of these estimates are not extremely accurate and can only serve as references when making decisions on policies. A comprehensive estimate based on the domestic production rates for the various types of equipment is that the domestic production rate for China's first set of 600MW nuclear power generators is about 70 percent.

Design of Secondary Loop at Qinshan NPP

936B0033A Beijing DIANLI JISHU [ELECTRIC POWER] in Chinese Vol 25, No 10, 5 Oct 92 pp 4-7

[Article by Wang Pei [3769 3099]: "Design of the Secondary Loop of the First Phase Project at Qinshan Nuclear Power Plant"]

[Text] Abstract: This article describes the design features of the secondary loop nuclear-grade portion of Qinshan Nuclear Power Plant, including its safety functions, safety grades, materials choices, design of the primary thermodynamic system, stress analysis of the nuclear-grade piping, and so on.

I. Overview

The first phase project at Qinshan Nuclear Power Plant is a 300MW pressurized-water reactor nuclear power plant studied, designed, and built by China itself that is composed of two main parts, a primary loop and secondary loop. The primary loop is the device that converts the heat energy released from nuclear fission in the reactor into steam, and is also called the nuclear steam supply system. Its main components are the reactor, main pumps, pressure stabilizers, steam generators, and so on. To ensure safety, all of the primary loop's facilities are installed inside the containment building. The secondary loop is the device that converts the heat energy in the steam into electricity and is also called the steam-motive power conversion system. It is composed mainly of the steam turbine generators, steam condensers, main steam system, feedwater system, and other auxiliary systems. The primary loop and secondary loop are two completely isolated sealed circulation systems. The primary technical parameters of the 300MW generators at Qinshan Nuclear Power Plant are:

Reactor thermal power	1,935MW
Reactor coolant inlet temperature	287.9°C
Reactor coolant outlet temperature	316.1°C
Reactor coolant working pressure	15.19 MPa
Number of loops in primary loop	2
Secondary loop steam pressure	5.54 MPa
Secondary loop steam temperature	271.53°C
Secondary loop steam flow rate	2,929 t/h
Secondary loop steam dryness	99.75 percent
Feedwater temperature	229°C

II. Safety Design of the Secondary Loop

A. Safety functions

The primary safety functions of the secondary loop at Qinshan Nuclear Power Plant are:

1. Residual heat removal function. When the steam turbines shed their loads, the excess steam after the

reactor automatically adjusts its power can pass through a bypass system or be discharged through atmospheric release valves to enable the reactor to continue operating. During the initial period of normal shutdown of the reactor, the main steam can be discharged into the steam condensers via the bypass system to remover the residual heat from the reactor. When the reactor is at normal shutdown or the steam turbines have shed their load and the steam condensers cannot operate because of a breakdown, the main steam can pass through the atmospheric release valves and safety valves and be discharged to remove the residual heat from inside the reactor until the reactor shutdown cooling system kicks in and safely shuts down the reactor.

2. Main steam isolation function. When a rupture accident occurs in the main steam piping, the rapid-closing isolation valves can be completely closed within 5 seconds of receiving the shut-off signal. If the main steam piping upstream from the rapid-closing isolation valves ruptures, causing a loss of control of the steam discharge from the steam generators, the rapid-closing isolation valves close to stop the steam in the other steam generator from being discharged through this break and prevent the accident from expanding. If the main steam piping downstream from the rapid-closing isolation valves ruptures, the rapid-closing isolation valves close, preventing the release of large amounts of energy and avoiding excess cooling of the reactor.

3. Feedwater piping isolation function. When a rupture accident occurs in the main steam piping, the feedwater electrical isolation valves can close within 20 seconds of receiving the shut-off signal. At the same time, the feedwater pumps trip and thus quickly cut off the feedwater, preventing excess reactor cooling caused by continuing the supply of water to the steam generators. When a rupture accident occurs in the feedwater piping, the feedwater electrical isolation valves can close within 20 seconds of receiving the shut-off signal to isolate the nuclear-grade and non-nuclear grade systems and simultaneously trip the feedwater pumps to rapidly cut off the feedwater to prevent the accident from expanding.

4. Over-pressure protection function. When there are transient pressure changes, the main steam is discharged through the safety valves to reduce the pressure of the main steam system to within 110 percent of the design pressure and prevent excess system pressure.

5. Radioactivity monitoring functions. When there is a leak in the steam generators and the radioactive water in the primary loop leaks into the secondary loop, causing radioactive contamination of the secondary loop, it can pass through the radioactivity monitoring devices on the air discharge piping of the air extractors and oxygen eliminators for immediate monitoring and isolation of leaks.

B. Safety grades

Safety grades for nuclear power plants are divided into safety grade 1, safety grade 2, safety grade 3, and non-safety grade based on the degree to which reactor safety is affected and the degree of radioactive contamination resulting from accidents. In addition, the corresponding design standards, quality grades, and earthquake resistance frequency divisions are determined based on each safety grade. The designs of safety grade systems have stricter requirements than non-safety grade systems, so correct delineation of safety grades and strict implementation of the corresponding design standards is an important link in ensuring that the systems perform their safety functions.

The safety grades for the secondary loop at Qinshan Nuclear Power Plant were established on the basis of United States standards. The main steam system upstream from the rapid-closing isolation valves and the main feedwater system downstream from the containment building's first electrical isolation valves are safety grade 2, while all of the other components are non-safety grade.

C. Materials selection

Neither copper nor copper alloy material can be used for any of the equipment or piping that comes into contact with the medium in the secondary loop. The primary structural materials used in the secondary loop at Qinshan Nuclear Power Plant are:

Super-grade piping	TU-48C
Main steam and feedwater piping	SA-106B
Steam condenser and water-water condenser	Titanium pipes and titanium sheets
Low-pressure heater piping	Stainless steel
High-proportion heater piping	Carbon steel

III. Design of the Main Steam System

The main steam system runs from the outlet of the steam generators to the main steam valves of the steam turbines and includes the super-grade piping, safety and atmospheric release valves, rapid-closing isolation valves, piping, and accessories.

A. Super-grade piping

The piping between the outlets of the components that penetrate the containment building and the rapid-closing isolation valves is called the super-grade piping. It has a nominal outer diameter of 660 mm and a minimum wall thickness of 50 mm. The pipe material is TU-48C, it has a design pressure of 7.55 MPa and design temperature of 320°C, and is safety grade 2. Its design must conform to the following requirements:

1. Based on ASME-III(NC) requirements, dynamic analysis of four working conditions—normal, disturbance, emergency, and breakdown—must be carried out and its stress should be within a limited range.

2. Every effort should be made to shorten the super-grade piping and no ruptures can be permitted during

operation because a rupture in the super-grade piping would inevitably release large amounts of steam from the steam generators connected to it and cause excess cooling of the reactor, which is an extremely dangerous working condition. To keep the super-grade piping from rupturing, its overall stress should be controlled to $\leq 0.8(1.2S_h + S_A$, where S_h in the formula represents the permissible stress on the material at the computed temperature and S_A expresses the range of permissible stress from thermal expansion.

3. Based on the safety standards for nuclear power plants, safety isolation walls are placed between two super-grade pipelines to prevent a rupture in one pipe from endangering the other pipe.

4. The design of the super-grade piping must take into account its own reliability as well as its effects on the non-nuclear grade piping connected to it. For example, the placement of pipe uncoupling limit stopers and bidirectional limiting supports at suitable places on the non-nuclear grade piping to withstand the energy from pipe uncoupling prevents the super-grade piping from being affected by ruptures of the non-nuclear grade piping.

5. The super-grade piping should have measures to protect against common aircraft crashes and flying material when the vanes of the steam turbines fracture. The configuration of the super-grade piping plant building structure should be designed according to the relevant nuclear-grade standards.

B. Safety valves

Safety valves are over-pressure protection devices for the steam generators and are in safety grade 2. Four spring horizontal safety valves are placed on each of the main steam pipes and are configured upstream from the rapid-closing isolation valves. The set pressure of each safety valve must be no greater than the design pressure of the steam generators. The set pressure of the last safety valve must not exceed 110 percent of the design pressure of the steam generators, and can be computed using the formula (1.1 X steam generator design pressure - ΔP)/ 1.03. The ΔP in the formula is the pressure drop from the steam generators to the safety valve intakes under full discharge conditions. The total discharge capacity of the safety valves should be not less than 105 percent of the "engineering safety design steam flow rate" and at this time the main steam pressure should not exceed 110 percent of the design pressure of the steam generators. The maximum permissible discharge capacity of each safety valve should not exceed the maximum permissible discharge amount of the reactor to prevent over-cooling accidents from occurring in the reactor.

Based on the extrapolations above, the set pressures of the four safety valves at Qinshan Nuclear Power Plant are, respectively, 7.25 MPa, 7.45 MPa, 7.64 MPa, and 7.84 MPa; their respective discharge flow rates are 296.16 t/h, 303.9 t/h, 312 t/h, and 319.8 t/h. Their total discharge flow rate is 2,463.8 t/h, which is 121.97 percent of the "engineering safety design steam flow rate".

C. Atmospheric release valves

The atmospheric release valves perform the function of reducing the number of times the safety valves are tripped and removing residual heat from the core, and are in safety grade 2. The set pressure of the atmospheric release valves is generally between the zero power steam pressure and first safety valve set pressure. The discharge capacity of the atmospheric release valves should satisfy the cooling rate requirements of 27.7°C/h in the reactor cooling process, and is usually 10 to 15 percent of the rated steam flow rate.

One pneumatically operated atmospheric release valve is placed on each of the main steam pipes at Qinshan Nuclear Power Plant between the safety valves and rapid-closing isolation valves. Their rated pressure is 6.62 MPa and the rated flow rate at this time is 132 t/h. The total flow rate of the two atmospheric release valves in the main steam system is 264 t/h, which is 13 percent of the rated steam flow rate. The atmospheric release valves have normal regulation and emergency response rapid action functions. The normal full-course regulation time is 15 seconds and the emergency response working conditions full course action time is no greater than 5 seconds.

D. Rapid-closing isolation valves

The rapid-closing isolation valves perform isolation functions to maintain the integrity of the pressure margin, and are in safety grade 2. Each of the main steam pipes at Qinshan Nuclear Power Plant is fitted with a rapid-closing isolation valve placed downstream from the safety valves. The rapid-closing isolation valves have a valve body fitted with an electromagnetic guide valve and each valve base is a Y-shaped steam self-actuating rapid action valve capable of going from fully open to fully closed in 5 seconds. The rated flow-through rate of each rapid-closing isolation valve is 1,010 t/h and the flow-through rate under accident working conditions is 2,020 t/h.

IV. Design of the Bypass System

The bypass system is capable of coordinating imbalances in steam supply rates between the reactor and steam turbines. During steam turbine startup, shutdown, and load shedding, this system discharges the excess steam after reducing its pressure and temperature into the steam condensers. The bypass system is in the non-nuclear safety grade. To make every effort to prevent the tripping of the safety valves, the bypass system must have a relatively large discharge capacity and fast action capability. The bypass system discharge capacity should take into consideration full load shedding by the steam turbines, reactor non-shutdown, and safety valve inaction. The discharge capacity of each bypass valve is the

same as the safety valves and must also be smaller than the reactor's maximum permissible steam discharge rate.

The discharge capacity of the bypass system at Qinshan Nuclear Power Plant is 70 percent of the steam generator rated steam output rate, which is 1,414 t/h, so the maximum discharge amount of each bypass valve is 353.5 t/h. Thus, the bypass system is configured with four bypass valves having identical discharge capacities, and these bypass valves have the rapid action capability of going from fully open to fully open within 3 seconds of receiving an actuation signal. They can also track the load operation of the steam turbines and have full-course regulation functions with a full-course operation time of 20 seconds.

V. Design of the Main Feedwater System

The design of the main feedwater system runs from the feedwater motherpipe at the outlet of the high-pressure heaters to the steam generator intakes and includes the pneumatic feedwater control valves, pneumatic bypass control valves, non-return valves, electrically-operated isolation valves, and the piping and accessories.

The main feedwater piping from the first electrically-operated isolation valves on the outside of the containment building to the intake of the steam generators is in safety grade 2, and its design requirements are the same as those of the main steam system. The pneumatic feedwater control valves and pneumatic bypass valves are placed upstream from the electrically-operated isolation valves and are in the non-nuclear safety grade. Their primary function is to control the feedwater flow rate. The feedwater control valve flow rate is 100 percent of the rated feedwater flow rate, while the flow rate of the bypass control valves is 20 percent of the rated feedwater flow rate. At startup and low loads, the bypass control valves are used for regulation. When the generator load is greater than 20 percent of the rated power, the feedwater control valves do the regulating. During normal operation, the feedwater control valves and bypass control valves have a full-course time of less than 20 seconds. During accident working conditions, they have a rapid closing time of less than 5 seconds.

The non-return valves are placed close to the outer side of the containment building to prevent feedwater pipe ruptures from causing the steam generators to "lose water" and "burn dry", and thereby be unable to remove heat from the core. In addition, to prevent the possibility of backflow occurring in the supplementary feedwater, the non-return valves must be installed upstream from the supplementary feedwater pipe connection.

The electrically-operated isolation valves are installed upstream from the non-return valves and perform a feedwater isolation function. When there is a rupture in the main steam piping or feedwater piping, the electrical isolation valves close within 20 seconds of receiving a closure signal and also trip the feedwater pumps to rapidly cut off the feedwater.

VI. Stress Analysis of the Nuclear-Grade Piping

The safety grade 2 piping for the main steam and main feedwater in the secondary loop are in the nuclear-grade system. According to ASME-III(NC) requirements, besides conducting static analysis of the nuclear-grade piping, dynamic analysis based on normal, disturbed, emergency, accident, and other working conditions must be carried out, including earthquake loads, steam (water) hammer loads, safety valve discharge counterforce, and other types of load combinations, and limits are placed on them based on four working grades: A, B, C, and D.

Because both the main steam and main feedwater systems both contain nuclear-grade and non-nuclear grade portions, fixed support points can usually be placed at the site of the boundary between the nuclear-grade and non-nuclear grade to isolate the thermal expansion of the nuclear-grade and non-nuclear grade pipe bundles so that stress analysis can be carried out for each of them separately. At Qinshan Nuclear Power Plant, because there was no way to place fixed support points due to the configuration of the piping, the scope of the dynamic analysis had to be expanded, meaning that stress analysis was carried out for the entire piping bundles including the non-nuclear grade ones based on nuclear-grade standards, which added a substantial deal of complexity, but the scope of the evaluation of the analytical results was restricted to the nuclear-grade piping.

The stress analysis indicated that both the nuclear-grade and non-nuclear grade portions of the main steam and main feedwater systems at Qinshan Nuclear Power Plant satisfied the ASME-III(NC) stress limit requirements and had a substantial safety margin. The results of stress analysis of the main steam system are given in the table below.

In the table:

PO is the calculated internal pressure;

DW is the static weight load (including the piping, insulation material, and other gravity loads that perform continuing roles);

TO is the thermal swelling load;

OBE is the operating baseline earthquake load;

FVO is the steam hammer load caused by rapid closing of the steam turbine main steam valves or main steam isolation valves;

SVO is the load created when the safety valves are discharging;

SSE is the safety shutdown earthquake load;

S_C is the permissible stress of the piping or pipe component materials below 20°C;

S_h is the permissible stress of the piping or pipe component materials below the computed temperature;

S_A is the permissible scope of thermal swelling stress stipulated by ASME-III(NC);

$S_A = f(1.25S_C + 0.25S_h)$

S_γ is the yield strength of the piping or pipe component materials above 20°C.

Table 1. Main Steam System Stress Analysis Table

Load condition	Calculated working condition number	Load combination mode	Stress value limit	Location of the point of maximum stress in the NC grade pipe segment	Calculated stress value (MPa)	Ratio of this stress value to the permissible stress	Standard equation checked
	2	TO	S_A	111	99.95	0.644	NC-3650 (Eq.10)
	3	TO	S_A	111	88.56	0.571	NC-3650 (Eq.10)
Normal conditions	4	TO	S_A	111	79.25	0.511	NC-3650 (Eq.10)
	40	PO+DW	S_h	164	43.20	0.418	NC-3650 (Eq.8)
	290	PO+DW+OBE	$1.2S_h$	150	107.65	0.867	NC- 3650 (Eq.9)
Disturbed working conditions	300	PO+DW+SVO	$1.2S_h$	164	45.78	0.369	NC-3650 (Eq.9)
	310	PO+DW+FVO	$1.2S_h$	153	49.76	0.401	NC-3650 (Eq.9)
Emergency working conditions	320	PO+DW+OBE+ FVO+SVO	$1.8S_h$	150	132.89	0.714	NC-3650 (Eq.9)
Accident working conditions	330	PO+DW+SSE+ FVO+SVO	$2.4S_h$	150	221.94	0.894	NC-3650 (Eq.9)
Rupture	340	PO+DE+ OBE+TO	$0.8(S_A + 1.2S_h)$	150	126.01	0.564	NC-3650 (Eq.9)+(Eq.10)
	360	PO+DW+ FVO+TO		111	100.53	0.456	
Water pressure test	50	PO+DW	$0.9S_\gamma$	164	57.02	0.263	—

Qinshan NPP Electrical Design Features Highlighted

936B0033B Beijing DIANLI JISHU [ELECTRIC POWER] in Chinese Vol 25, No 10, 5 Oct 92 pp 8-10, 3

[Article by Jia Hongbin [6328 7703 2430]: "Design Features of the Electrical Portion of Qinshan Nuclear Power Plant"]

[Text] Abstract: This article begins with the inherent features, self safety requirements, safety protection, and other areas to point out some differences between pressurized-water reactor nuclear power plants and thermal power plants. It also introduces the main electrical connections, plant power use connections, control room and DC system, and other parts at Qinshan Nuclear Power Plant to satisfy requirements in safety and other areas, for reference on advice and views in foreign countries, and adopting measures in conjunction with actual conditions in China.

The 300MW generators at Qinshan Nuclear Power Plant utilize a pressurized-water reactor (PWR), wet saturated steam full-speed steam turbines, and dual water internal cooling generators. The design for the conventional island took into consideration the relevant articles from China and foreign countries and advice from the EBASCO Corporation in the United States. This article provides a brief introduction to the design principles and characteristics of the electrical portion.

I. Design Principles of the Electrical Portion

A. The design was prepared according to the following requirements for a pressurized-water reactor nuclear power plant

1. The nuclear power plant only carries base loads in the electric power system and does not participate in peak regulation.

2. When an irresistable natural disaster (earthquake, flooding, etc.) or unusual disaster (aircraft collision,

turbine blade fly-out, full-grid power outage, etc.) occurs, it should also guarantee safe reactor shutdown.

3. The reactor generates wet saturated steam.

4. Leaks of radioactive material from inside the reactor at any time should be within the stipulated value.

5. When a single accident occurs (such as a flame-out), it should be capable of a reactor shutdown.

6. For safety, the reactor control rods must drop freely under power outage conditions to control the reactivity.

B. Adaptation to all types of working conditions in the primary loop

There are also several features such as the boron operation mode, scheduled fuel replacement, and so on that should be taken into consideration in the design.

C. The electrical equipment is divided into IE grade and non-IE grade

The electrical equipment in a nuclear power plant is usually divided into two categories: IE grade and non-IE grade. The electrical equipment related to reactor safety is in the IE grade and the remainder is in the non-IE grade. Usually the requirements for IE grade equipment in the areas of electrical performance, mechanical performance, or reliability are higher than non-IE grade electrical equipment. For example, IE grade equipment must pass earthquake tests (under conducting conditions). China so far has not yet formulated concrete norms and standards for this. The standards stipulated by the United States Nuclear Regulatory Commission (NRC) were adopted for the design of Qinshan Nuclear Power Plant. The demarcation of the scope of IE grade equipment also varies among different countries, so we will now refer to the IEEE-308 standards.

D. Safety analysis and quality assurances

The differences between the content of the design for the electrical portion of a nuclear power plant and a thermal power plant are: the design for a nuclear power plant must also compile a "Safety Analysis Report" (divided into preliminary and final types) and the design and production (or product manufacture) must implement "Quality Assurances" (abbreviated as QA). Compilation of the "Safety Analysis Report" refers to each system in the entire plant, and the electrical portion is only a small part. The participation of the electrical portion in compilation of the "Safety Analysis Report" can mean providing material for the other systems, or participation in compilation of a certain portion.

For the "Quality Assurance" item, the production plants for the main electrical equipment used at Qinshan Nuclear Power Plant (such as the generators, transformers, GIS, etc.) have established or are in the initial stages of establishing quality assurance systems. A quality assurance system for the design area has yet to be established and perfected.

II. Design Features of the Electrical Portion

A. Main electrical connections

Given the safety considerations for nuclear power plants and the requirement that they only carry base loads and do not participate in peak regulation, the electrical connections that were designed (see Figure 1) have the following characteristics.

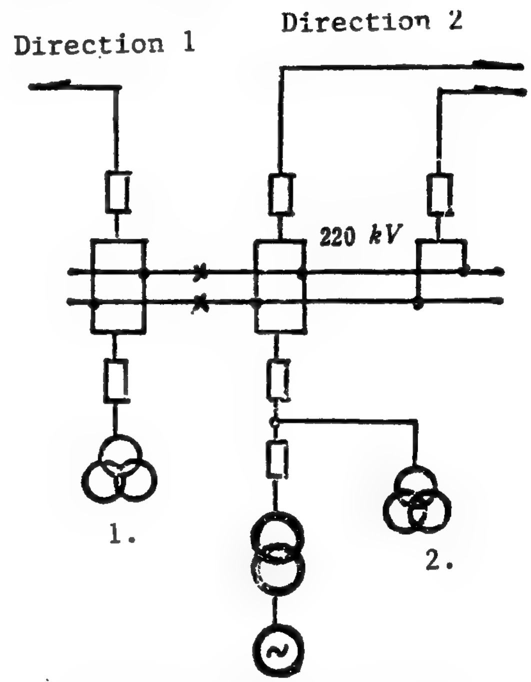

Figure 1. Main Electrical Connections

Key: 1. Startup/reserve transformers; 2. Working plant transformers

1. The three power transmission lines are divided into two different directions of entry and the lines in the same direction have dual loop frames on the same poles. The task of the lines in direction 2 is to transmit the 300MW of electricity to the power grid. The primary task of the line in direction 1 is to guarantee the plant-use power source for the nuclear power plant. The transformer site connected to the line in direction 1 is located very close to two thermal power plants and the two power plants have mostly small generators (one plant has four 50MW generators and the other plant has two 100MW and one 30MW generators), so the restoration of power supplies in an accident will be very fast. The original design idea was for the line in direction 1 to use a 110 kV voltage so that the voltage (220 kV) of the line in direction 2 would not be at the same grade, which would help reduce the probability of a total power outage. However, an on-site survey showed that the breakdown rate for the 110 kV line was higher than the 220 kV line, and moreover, the 110 kV line from Qinshan Nuclear Power Plant to the thermal power plants was very long and could not meet

the requirement for a secure power source. Given these things, the main connection design utilizes a program with lines coming in from two different directions to prevent a pole collapse from causing a full-plant power outage accident.

2. The 220 kV booster station uses SF_6 fully-sealed assembly components. The accident rate of the booster station itself must be lower than 10^{-4} and require very little maintenance work during normal operation.

3. During the period of counter transmission of power, a working plant-used transformer and startup/reserve transformer are used for a dual power transmission arrangement. Prior to normal startup of the reactor, it must be confirmed that everything in the grid is normal. During the startup process, if there is an accident in one loop of the dual loop power transmission lines of the working plant-used transformers or startup/reserve transformers, this could delay the startup schedule or stop the startup, and it should not be connected to the grid and generate power.

4. To facilitate counter power transmission of the working plant-used transformers, a voltage of 220 kV was selected for their power source and they have a load regulated voltage. Dynamic simulations confirm that using this type of connection arrangement is feasible and that accidents on the 220 kV side would not have a significant impact on the reactor's main circulation pumps (abbreviated as the main pumps). The reason for this is that the main pumps are fitted with large flywheels that have substantial rotational inertia which is seven times that of similar generators.

5. The nuclear power generators carry the base load and the load cannot be randomly raised or lowered. The United States NRC stipulates several detailed principles: when a nuclear power plant loses one loop of its external power source, the reactor does not reduce power. It continues to maintain present operation for a period of time and can continue operating if the external power source is restored. In contrast, the reactor should be in a hot shutdown or cold shutdown state. Although at this time there are no breakdowns in the reactor and steam turbine generators themselves, this type of operation is stipulated for safety reasons. This design also strictly observes this principle.

B. Plant-use power connections

The 6 kV plant-use power is divided into three main parts: working segment, public segment, and safety segment. The plant-use power connections are illustrated in Figure 2.

1. Working segment

The plant-use working segment mainly involves supplying power for assuming the normal operating load (include the low-voltage 380 V load). The reactor's main pumps can only be connected in the working segment to allow the inertia of the generators to be used to supply power during full-plant power outages to prevent the core from burning up.

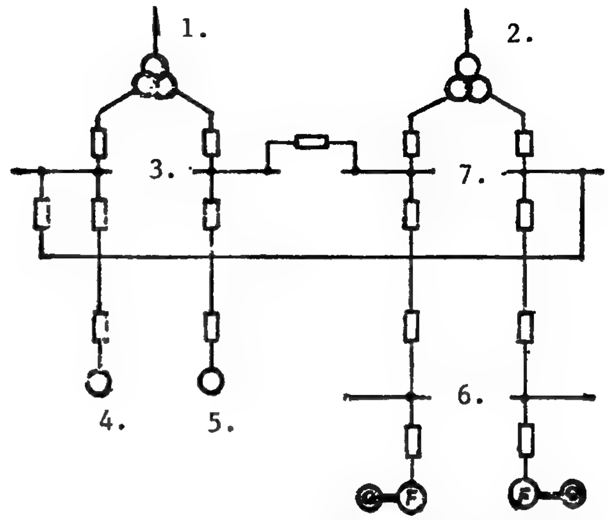

Figure 2. 6 kV Plant-Used Electrical Connections
Key: 1. Working plant-used transformers; 2. Startup/reserve transformers; 3. Working segment; 4. Main pump; 5. Main pump; 6. Safety segment; 7. Public segment

2. Safety segment

All of the loads connected to the plant-used safety segment are those that must be used when a reactor accident occurs. A group of diesel generators serves as an emergency response power source. When the diesel generators receive a startup order, they must complete the startup process within 10 seconds. At the same time as they receive the order to start up the diesel generators, all of the switches on the safety bus must be opened up and leave an empty bus to facilitate connection by the diesel generators. Normally, the diesel generators are in a hot reserve state. In the event that they cannot be in a hot reserve state, this is dealt with in accordance with the regulations for the loss of one circuit or two power sources (this is also one period of operation and if restoration cannot be done, this is dealt with by shutting down the reactor).

3. Public segment

All of the loads connected to the public segment are the entire plant's public loads, and normally all of the loads are very small. The centralized water supply and electricity supply portions are connected through the transformer site to the public segment. The primary function of the public segment is to supply electricity to the safety segment during normal operation. When there is a breakdown in the working segment, they serve as a

reserve power source and supply electricity to the working segment. However, the hope is that usually this measure will not be used, because a breakdown in the working segment would leave only 0.5 seconds of time to eliminate the breakdown or switch power sources. If it exceeded 0.5 seconds, this would have to be dealt with by shutting down the reactor. When the reactor is shut down, usually there is a hot reactor shutdown first and when the hot reactor is restored to full power electricity supplies, the power can be raised based on the reactor at 5 percent/minute. If the reactor is in a hot shutdown state for no more than 5 hours, restoring the power supplies is not difficult.

There are also some aspects of the plant-use power design that are different from thermal power designs:

1. In configuration, only the safety segment is placed in the nuclear island region, so it is based on IE grade equipment design. However, the working segment and public segment are placed in the conventional island region. Doing this satisfies the need mentioned in item (2) above to guarantee a safe reactor shutdown. The main pump loop and the loop from the safety segment to the public segment are both connected by dual-switch series connections. The goal is to prevent the switches from refusing to activate when an earthquake occurs, so one of the dual series connected switches must be placed on the nuclear island.

2. Because the reactor produces wet saturated steam, besides having to adopt measures when the steam turbines are operating at excess speed, the system also uses a steam bypass method. When the steam bypass system is being used, the 6 kV working segment often has no electricity, so to maintain a specific degree of vacuum in the condensers, one each of the circulation water pumps, condensed water pumps, and condensing pumps is connected to the public bus segment.

3. The safety measures adopted for the reactor control rod drive mechanism are: when there is a loss of power, the pawls of the drive mechanism open up and the control rod bundles drop automatically by gravity down into the core. The power source of the control rod drive mechanism is composed of two electrically-operated generator groups (see Figure 3). To match the rod power source generators to the power grid, each of the generators is fitted with a flywheel to increase the rotational inertia of the generators. Having this inertia can sustain the power supply for a period of time, and this time is matched to the switch reclose time for the 220 kV circuit and the power source switchover time for the 6 kV bus. Neither the normal range of fluctuation of the system operating frequency nor the normal range of fluctuation of the AC 380 V bus voltage have any effect on the supply of power to the rod power source generators.

4. Many loads (such as the main pumps, upper filling pumps, spray pumps, etc.) all are sealed inside the reactor building. During normal operation and accident states, radioactivity exists inside the reactor building, especially when the reactor is completely sealed under accident conditions. Inside the building, besides the high radioactivity dose, there are also temperatures as high as 135°C and pressures as high as 294 MPa (surface pressure). The electrical cables that run in and out of the reactor building and the other piping and so on have to be sealed. Thus, an electrical feed-through component method is used to connect the electricity inside and outside the building. It is resistant to temperatures of 150°C and resistant to pressures of 392 MPa (surface pressure), and has a leakage rate of 10^{-2} cm^3/s, and are a part of the outer casing.

C. Control room and DC system

1. The control room is divided into a main control room and emergency control room. There is one main control room. Its function is similar to that of the centralized generator, boiler, and electrical control room in a thermal power plant and it implements open-loop control. Its configuration is identical to a typical control room but has improvements over thermal power plants in the area of computer applications and television monitoring and control. The most prominent aspect is that the nuclear island control and protection systems are both divided into A and B parts. The two main parts

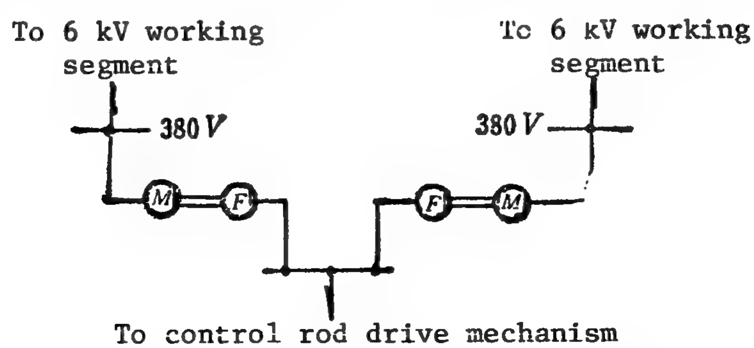

Figure 3. Illustration of Rod Power Source Assembly

are nearly identical and either of the parts can independently complete safe reactor shutdown tasks. The electrical cables connected to the A and B equipment take two A and B paths and the two are mutually isolated from each other. The portion that runs to the conventional island takes path C and is totally separate from paths A and B. Both path A and path B have an emergency control room and the two have completely identical functions. They respond to a loss of function of the main control room and carry out an emergency reactor shutdown. This is done to prevent a single accident (such as a fire at a location where electrical cables are concentrated) from affecting a reactor shutdown.

2. The DC system is divided into a conventional island and nuclear island DC system. The nuclear island DC system uses two groups of totally independent DC power source systems. The conventional island has a group of storage batteries (like the 300MW generators at thermal power plants) and are connected by an electrical cable to the nuclear island DC power source. There is an interlock between the two, so when the nuclear island storage batteries are used the conventional island storage batteries cannot be used, and vice versa. Some people have suggested eliminating this connecting cable to ensure the reliability of the nuclear island DC system, and this suggestion deserves study.

D. Other

1. The reactor has a 2-month reactor shutdown fuel replacement period each year, so checking and inspection of the electrical equipment on several of the circuits can be carried out during the fuel replacement period.

2. The equipment inside the reactor should avoid using any elements that are easily activated by radiation such as zinc, fluorescent powder, etc. Thus, no zinc-plated components are permitted for the electrical equipment supports inside the building, nor are fluorescent lights unless protection measures are adopted or the total amount of the elements is smaller than the stipulated value.

3. The frequency spectrum for seismic testing of the electrical equipment is provided by the overall project department.

4. Fireproof cables are used for basically all of the electrical cables and LOCA experiments should be conducted on the electrical cables used in the reactor plant building. Irradiation-resistant electrical cables should be used for all of the cables used in radioactive plant buildings.

5. Special requirements are also placed on communication cables and they are not described further here.

III. Conclusion

China so far has not formulated complete standards for the conventional island design of a nuclear power plant. During the design process for the electrical portion of Qinshan Nuclear Power Plant, we tried to reflect issues that had already been considered internationally in conjunction with actual conditions in China. The above design principles will receive further examination and confirmation in practice.

Quality Assurance at Qinshan Nuclear Power Project

936B0039A Beijing DIANLI JISHU [ELECTRIC POWER] in Chinese Vol 25, No 12, 5 Dec 92 pp 30-32

[Article by Li Shangwei [2621 1424 0251] of the Qinshan Nuclear Power Company: "Quality Assurance at the Qinshan Nuclear Power Project"]

[Text]

I. Preface

As the economy grows, demand for energy resources will continually increase and reserves of mineral fuels will continually decline, so the development of new energy resources and the development of nuclear power have been publicly acknowledged by the world. At the end of 1991, the world had completed a total of 429 nuclear power plants and another 83 nuclear power plants were under construction. Nuclear power as a proportion of total power output (in 1990) was 74.5 percent in France and over 40 percent in Belgium, Hungary, South Korea, Sweden, Switzerland, and other countries. As China's national economy has grown and our people's living standards continue to rise, demand for energy resources has grown quickly, so developing nuclear power in the industrially developed and densely populated East China region, which is distant from coal and hydropower resources, has become essential. To ensure the safety of nuclear power plants and spur the development of China's nuclear power industry, Qinshan Nuclear Power Plant must adhere to the nuclear power development principle of "safety first, quality first", and it must implement nuclear safety laws and regulations and do good quality assurance work.

China joined the International Atomic Energy Agency (IAEA) in 1984 and established the National Nuclear Safety Administration in October 1984. The State Council approved the promulgation of four nuclear safety regulations including the "Nuclear Power Plant Quality Assurance and Safety Stipulations" (HAF-0400) by the National Nuclear Safety Administration on 7 July 1986. The State Council promulgated the "People's Republic of China Civilian Nuclear Facility Safety Supervision Management Regulations" in October 1986. Implementation of all of these "laws" and "regulations" is compulsory and the National Nuclear Safety Administration implements supervision of civilian nuclear facilities, including nuclear power plants, in accordance with these "laws" and "regulations". Moreover, they are subject to IAEA safety evaluations of nuclear power plants, and so on.

The first vat of concrete was poured at the Qinshan Nuclear Power Plant project in March 1985, hydraulic testing of the reactor's primary coolant system was successful on 5 November 1990, the first heat of nuclear fuel was loaded on 8 August 1991, and it was connected to the grid and began generating power at the end of 1991.

In early 1987, the former Qinshan Nuclear Power Plant Project Headquarters and Qinshan Nuclear Power Plant were combined to form the Qinshan Nuclear Power Company, which established a Quality Assurance Department, formulated a quality assurance program, and established a quality assurance system that has operated effectively. An evaluation by PREOSART experts from the IAEA in April 1989 felt that the quality assurance work was comprehensive and well-organized, and that it permeated all aspects of the project. They were satisfied with the quality assurance program and the QA and QC procedures that were formulated. Nothing was discovered that endangered the completion of construction or the safe startup of the completed nuclear power plant.

II. The Quality Assurance Program at the Qinshan Nuclear Power Plant Project

HAF-0400 stipulates: "To ensure the safety of nuclear power plants, an overall quality assurance program for a nuclear power plant and a quality assurance program for each specific item of work (for example, design, manufacturing, construction, debugging, and operation) must be formulated." For this reason, after the Qinshan Nuclear Power Company was established it immediately began working to formulate a quality assurance program for the Qinshan Nuclear Power Company, the Qinshan Nuclear Power Project Overall Quality Assurance Program, which underwent examination and certification by the National Nuclear Safety Administration in accordance with the requirements in State Council Document 15 at the end of March 1987. It was issued to the primary contractors and internally to Qinshan Nuclear Power Company on 10 April 1987 and its implementation began.

The goal of the Qinshan Nuclear Power Company Quality Assurance Program was to ensure safe, reliable, stable, and economical operation of the first nuclear power plant designed and built by China itself.

The appropriate scope of the Qinshan Nuclear Power Company Quality Assurance Program includes design, manufacture, construction, debugging, operation, and other items of work at the Qinshan nuclear power project.

The Qinshan Nuclear Power Company Quality Assurance Program satisfies the requirements in HAF-0400.

The Qinshan Nuclear Power Company Quality Assurance Program clearly points out that all units responsible for a nuclear power project (including design, manufacturing, construction, debugging, operation, and others) must formulate quality assurance sub-programs that correspond to their work and undergo examination and certification by the Qinshan Nuclear Power Company Quality Assurance Department. To ensure effective implementation of quality assurance and the overall program, sub-program units must accept quality assurance supervision by the Qinshan Nuclear Power Company.

The Qinshan Nuclear Power Company Quality Assurance Program is divided into 13 chapters including: overall principles, the quality assurance program, organizational structures, document management, design management, purchasing management, materials management, process management, inspection and testing management, control of non-conforming items, corrective measures, records, and quality assurance supervision, and three appendices for the safety grades of structures, systems, and components, earthquake resistance grades, and quality grades.

III. The Qinshan Nuclear Power Project Quality Assurance System

To implement the Qinshan Nuclear Power Company's Quality Assurance Program and guarantee the quality of the Qinshan nuclear power project, a quality assurance system was established and perfected in accordance with the policy declarations in the Qinshan Nuclear Power Company Quality Assurance Program for effective operation.

The following diagram illustrates the Qinshan nuclear power project's quality assurance system:

To make the quality assurance system truly perform its role, we must devise ways to make it operate effectively. To do this, we must focus on examination and certification of the quality assurance sub-programs, quality supervision, control of non-conforming items, quality assurance supervision, and other important links for the contractors.

A. Examination and certification of the quality assurance sub-programs of contractors

All of the design, manufacturing, construction, debugging, operation, and other units and departments involved in nuclear power projects must compile quality assurance sub-programs. To ensure that all of the sub-programs conform to the legal requirements of the National Nuclear Safety Administration and to ensure that all of the sub-programs satisfy the requirements of the overall program, we must examine and certify the quality assurance sub-programs of all primary contractors. All sub-programs must clearly implement the state's nuclear safety requirements and satisfy the requirements set forth in the overall program, and they must clearly establish quality assurance organizational structures and give them sufficient authority and independence and clearly accept inspection, supervision, and monitoring by operating units to ensure correct interface relationships among them and close and organic cooperation

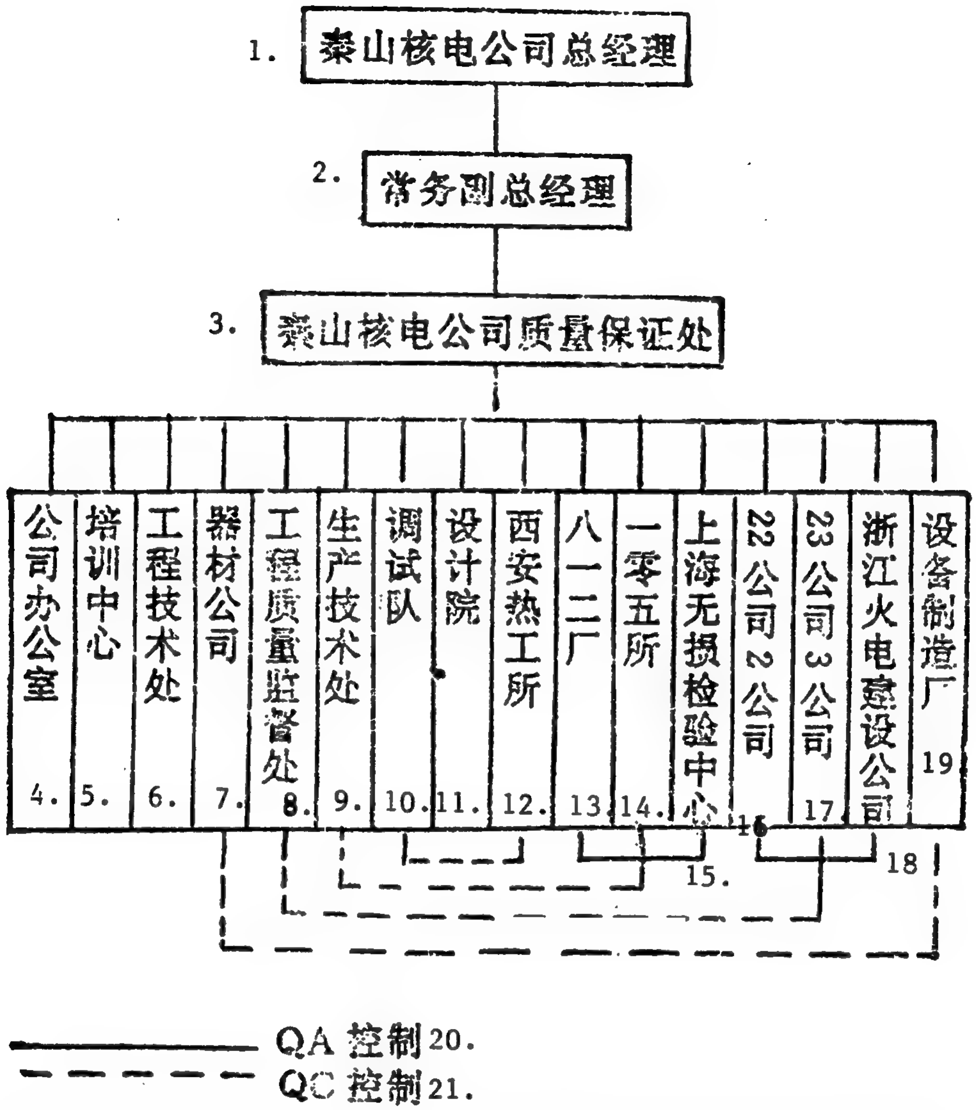

Figure 1. Diagram of the Quality Assurance System at the Qinshan Nuclear Power Project

Key: 1. General manager, Qinshan Nuclear Power Company; 2. Routine assistant general manager; 3. Qinshan Nuclear Power Company Quality Assurance Department; 4. Company offices; 5. Training Center; 6. Engineering and Technology Department; 7. Materials Company; 8. Engineering Quality Supervision Department; 9. Production Technology Department; 10. Debugging teams; 11. Design academies; 12. Xi'an Thermodynamics Institute; 13. Plant 812; 14. Institute 105; 15. Shanghai Non-Destructive Testing Center; 16. Company 22 Second Company; 17. Company 23 Third Company; 18. Zhejiang Thermal Power Construction Company; 19. Equipment manufacturing plants; 20. QA control; 21. QC control

during the program implementation process to guarantee that the quality assurance program is effectively implemented and ensure quality.

The Qinshan Nuclear Power Company has already issued written documents with clear requirements that the 22 main contractors in China provide examination and certification of the quality assurance program (the contractors from foreign countries were already certified during the contract negotiation process). There are 37 sub-programs that have actual undergone examination and certification on one or two instances, which on the one hand can guarantee the quality of the sub-programs and on the other hand has improved the quality reputations of the sub-program units who have been examined and certified by China's first nuclear power plant operating unit.

B. Quality supervision

To ensure the quality of important materials and services for the Qinshan nuclear power project, we must implement quality supervision at different levels. Quality assurance and quality control departments in the Qinshan Nuclear Power Company have implemented planned and focused effective supervision of the quality of important materials and services. This was also the highest-level supervision.

Qinshan Nuclear Power Company and the contractors jointly negotiated and signed a quality control point plan that includes written witness points, on-site witness points, and construction shutdown for inspection points. The witness point plant includes the time, place, mode, personnel, content, and so on of the witnessing. The number of points selected and the mode should first of all take into consideration the need for quality assurance and not leave out important work procedures or quality links. Secondly, they should take into consideration differences between different levels and cannot entirely repeat the inspections made by the contractors themselves. They should also take into account possibilities and other factors. For example, they formulated 446 witness points for the reactor pressure vessel, 140 witness points for the reactor body, 163 witness points for the control rod drive mechanisms, 83 witness points for the steam turbines, 230 witness points for the welding of the main piping, 132 witness points for inspection of nuclear-grade components prior to their going into service, and so on.

Inspection and acceptance of the manufactured equipment as it leaves the plants is another important link in quality verification and purchasing departments in the Qinshan Nuclear Power Company have been closely concerned about it. They have delineated different grades and formulated an inspection and acceptance program for each type of equipment, the Quality Assurance Department has carried out quality assurance inspections of the examination and acceptance programs and done examination and acceptance in accordance with the main program. Specialized groups for overall matters, materials, quality assurance, and so on were established during the examination and acceptance and the relevant experts were recruited to conduct the examination and acceptance. There are 51 main types of equipment manufactured in China that underwent examination and acceptance in accordance with the examination and acceptance programs. Examination and acceptance at the plant gates was carried out for equipment from foreign countries and large equipment that was delivered in lots, as was final examination and acceptance after installation, to ensure that its quality attained the technical indices stipulated in the contracts.

C. Control of non-conforming items

Implementing effective control of non-conforming items is extremely important, and it is a rather sensitive and difficult issue during the initial stages of implementing quality assurance provisions. It is also one of the main indicators for checking whether or not the mutual interfaces and quality assurance systems are operating normally. To manage non-conforming items properly, the Quality Assurance Department has formulated three special non-conforming items management procedures for materials purchasing, construction, and debugging. There are provisions in the procedures regarding the authority and interface relationships of the Qinshan Nuclear Power Company concerning technology and quality assurance inspections for the creation of non-conforming items. The procedures also divide the non-conforming items into three levels, regular, relatively important, and important, and stipulate the qualifications of inspection personnel in terms of technology and quality assurance for non-conforming items at different levels as well as procedures for dealing with non-conforming items at different levels. Independent inspection by the buyers of non-conforming items that have been returned for repairs is extremely important. The occurrence of non-conforming items during the manufacturing and construction processes for a nuclear power plant is understandable, but it must be dealt with appropriately. Moreover, immediate discovery, proper handling, and implementation of effective control are the keys to not endangering safety.

D. Quality assurance supervision

To verify the effectiveness of the quality program and promote effective operation of the quality assurance system, supervision of quality assurance must be undertaken regularly and in a planned manner based on legal requirements. For historical reasons, quality assurance work in the Qinshan nuclear power project has been retrospective, which has posed several problems for supervision of quality assurance, but we still conduct planned quality assurance supervision of the design, manufacturing, civil engineering, installation, and other primary contractors and internally in the Qinshan Nuclear Power Company in accordance with the stipulations in the main quality assurance program. The supervision is carried out in accordance with the guiding principles and the IAEA Quality Assurance Supervision Handbook. Problems discovered through supervision are immediately corrected, which has established the status of the proprietor, increased the prestige of their quality assurance departments, promoted effective operation of the quality assurance system, verified the effectiveness of the quality assurance program, and aided in effective implementation of the quality assurance program. When we had just begun carrying out quality assurance supervision of the contractors in 1987, a few contractors had misgivings and were unwilling to accept it. After several years of practice, however, when they came to understand the significance of quality assurance supervision and its advantages, several contractors took the initiative in requesting that the Qinshan Nuclear Power Company carry out quality assurance supervision.

IV. Conclusion

While many achievements have been made in quality assurance work at the Qinshan nuclear power project and we have gained considerable experience, we still lag behind the legal requirements and in the future we must continually practice, continually summarize, and continually improve to contribute to the quality and safety of Qinshan Nuclear Power Plant and the development of China's nuclear power industry.

Operational Safety Analysis at Qinshan Nuclear Power Plant Project

936B0039B Beijing DIANLI JISHU [ELECTRIC POWER] in Chinese Vol 25, No 12, 5 Dec 92 pp 33-35

[Article by Wang Wenshi [3769 2429 0099] of the Qinshan Nuclear Power Company: "Operational Safety Analysis Work at Qinshan Nuclear Power Plant"]

[Text]

I. Overview

Nuclear safety law HAF300, "Nuclear Power Plant Operational Safety Stipulations", clearly points out that the operating unit of a nuclear power plant has overall responsibility for safe operation of the nuclear power plant. To adhere to the principle of "safety first, prevention as the main factor", concentrating our forces to strengthen operational safety work is particularly important for the Qinshan Nuclear Power Plant.

For this reason, we must formulate a series of safety analysis management procedures, establish the corresponding organizations, and give them the appropriate authority to undertake operational safety inspection and evaluation work to enable checking of whether or not operational safety is consistent with the goals of the stipulations. When deviations from objectives, system and equipment malfunctions, and other abnormal conditions are discovered, we can immediately adopt effective measures to prevent accidents from occurring or expanding and guarantee that people, equipment, and the environment are not endangered.

II. The Division of Labor in Responsibility for Operational Safety Analysis Work at Qinshan Nuclear Power Plant

In Qinshan Nuclear Power Plant, the operating personnel, technical and management personnel, and specialized organizations form an operational safety analysis network in which each has stipulated responsibilities in taking on operational safety analysis tasks.

A. On-duty personnel at operating posts

Operating personnel continuously monitor and control technical system operating states on the screens at their posts, make scheduled on-site roving inspections, immediately report the occurrence of abnormal situations and determine their causes, and immediately deal with them to prevent them from developing into accidents. They make detailed records of all abnormalities and accidents.

B. Operation, inspection and repair, and management departments

Operational technology management personnel go to the site every day to gain an understanding of the operational conditions, do preliminary surveys of abnormalities and accidents that occur, analyze trends and outcomes, and turn them into written information that is submitted to the Independent Engineering Safety Group in the Production Technology Department.

Inspection and repair technical management personnel go to the site every day to gain an understanding of equipment defects and malfunctions, and organize inspections and repairs to deal with them. The Power Department analyzes and evaluates equipment defects and malfunctions and measures to deal with them, which it turns into written information that is submitted to the Independent Engineering Safety Group in the Production Technology Department.

C. Independent Engineering Safety Group

The Independent Engineering Safety Group is composed of 5 to 8 experienced experts and is a special organization for operational safety analysis work at Qinshan Nuclear Power Plant. Its administrative relationships place it under the jurisdiction of the Production and Technology Department and in its work it is directly responsible to the plant manager and chief engineer.

The Independent Engineering Safety Group will collect information for immediate analysis and discussion, and all major safety problems will be reported to the plant's leadership and turned over to the Operations Commission for discussion. Regular problems are reported in groups to the Operations Commission.

The Independent Engineering Safety Group is responsible for drafting written documents and, after being examined and approved by the plant leadership, they notify or report to the National Nuclear Safety Administration and its Shanghai Supervision Station concerning safety incidents.

D. Qinshan Nuclear Power Plant Operations Commission (QOC)

The Operations Commission conducts scheduled inspections and evaluations and submits proposals regarding nuclear power operations work. Under normal conditions, it holds one meeting a month to discuss operational safety issues. If the situation demands, it can also hold meetings at any time. The Operations Commission has direct responsibility to the chief engineer. The members of the Operations Commission hold two positions and are composed of important technical cadres from the relevant departments.

E. Qinshan Nuclear Power Plant Safety Commission (QSC)

The Safety Commission is responsible for independent inspection tasks concerning the operational safety of the nuclear power plant. It mainly examines major safety problems during the period of nuclear power plant operation and major changes in systems and equipment. Under normal conditions, it holds one meeting each quarter and can hold interim meetings in special situations. The Safety Commission is directly responsible to the plant manager and its members hold dual posts. They are composed of higher level key technical cadres in the enterprise.

III. The Inspection and Evaluation Process for Important Safety Analysis Work

The content of safety analysis activities at Qinshan Nuclear Power Plant is very broad, but in essence it includes three main areas: safety analysis supervision activities of operational states; inspection and evaluation activities for revision work that affects nuclear safety regulations and systems; inspection and evaluation activities for changes to the original design of systems and equipment that affect nuclear safety.

A. Safety analysis supervision activities of operational states

When the nuclear power plant is in stable operation and there are abnormal or accident states caused by system or equipment malfunctions, personnel operations, or other factors, operational safety analysis must be organized after the event to absorb experiences and lessons and guide future operations work. Figure 1 is a diagram of the abnormality and accident analysis process.

B. Revision, inspection, and evaluation of nuclear safety regulations and systems

To satisfy the requirement for safe operation, there must be scheduled examinations and timely revisions of regulations and systems. Revisions to the regulations and system related to nuclear safety must observe specific inspection procedures (see Figure 2) [not reproduced].

C. Inspection and evaluation of changes in nuclear safety systems and equipment

Based on nuclear safety laws, all changes to important structures, systems, and equipment that affect safety must be reported prior to implementation to the National Nuclear Safety Administration for approval. All revisions must respect HAF200, "Nuclear Power Plant Design Safety Stipulations", and must not reduce the ability to implement safety functions. The inspection and evaluation activities process is illustrated in Figure 3 [not reproduced].

IV. Guidance of Operational Safety and Analysis Work

Operational safety analysis work at Qinshan Nuclear Power Plant must accept guidance by the China Nuclear Industry Corporation's Nuclear Power Bureau and use daily reports, monthly reports, annual reports, and other written materials to report on the operation, inspection and repair, and safe production situations at the power plant to the Nuclear Power Bureau. The Nuclear Power Bureau and the technical backup units under its jurisdiction (such as the Nuclear Power Operation Institute, etc.) do immediate analysis of the operating conditions at Qinshan Nuclear Power Plant and feed back their views and proposals to the power plant operating unit to instruct or guide its safe and economical operation.

V. Conclusion

Nuclear power plant operational safety analysis work is very important for the safe operation of Qinshan Nuclear Power Plant. Because Qinshan Nuclear Power Plant just went into operation, the related nuclear power plant safe operation analysis work stipulations and work processes it has established must still be tested in practice. We will use the problems that appear in operation of Qinshan Nuclear Power Plant and our experience in operational safety analysis as a basis for continual perfection and revision of the existing relevant stipulations and safety analysis work processes to ensure safe operation of Qinshan Nuclear Power Plant.

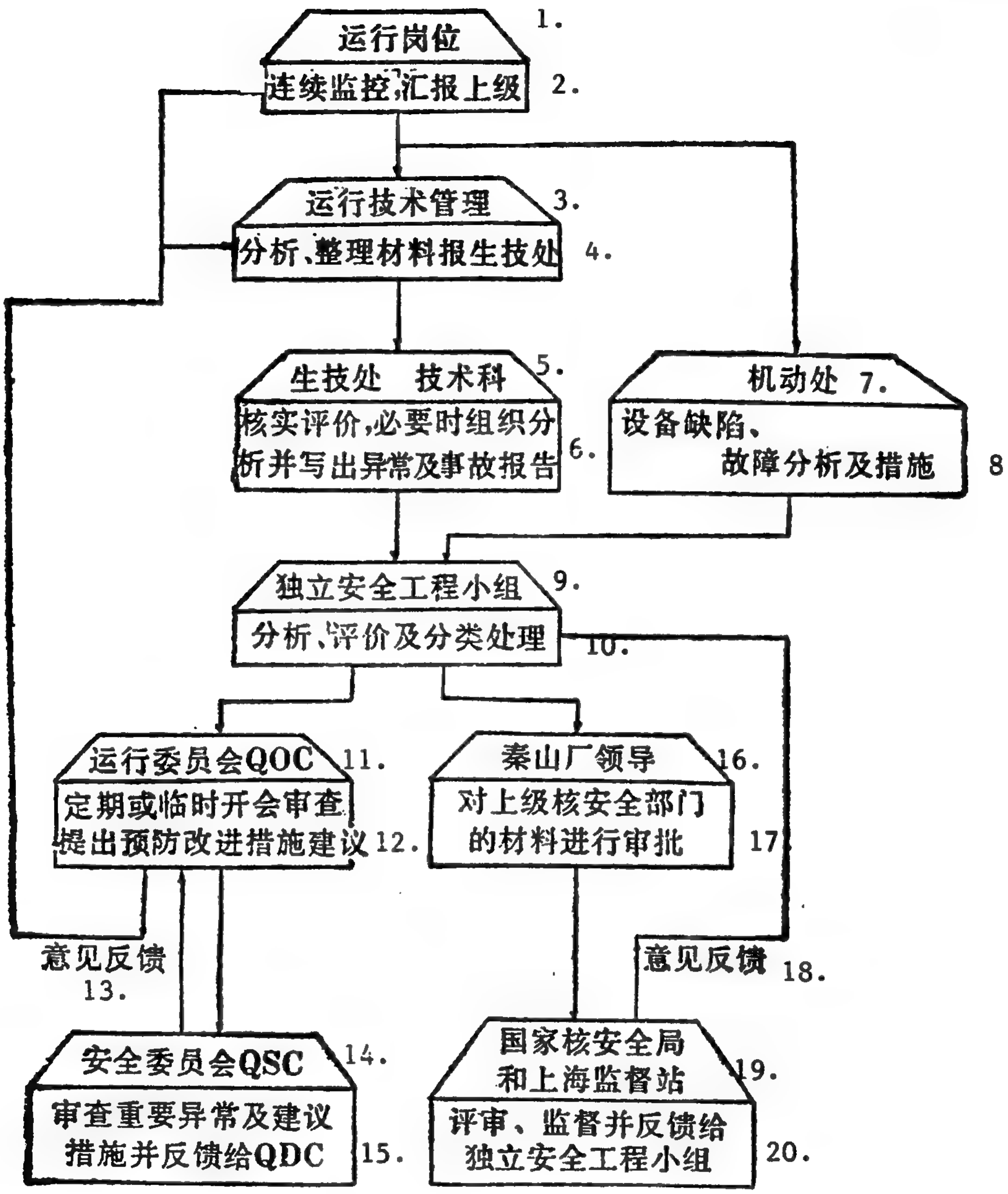

Figure 1. Diagram of Process for Analyzing Abnormalities and Accidents

Key: 1. Operating posts; 2. Continuous monitoring and control, reporting to higher authorities; 3. Operational technology management; 4. Analysis and preparation of information for reporting to the Production Technology Department; 5. Production Technology Department, Technology Section; 6. Checking and evaluation, organizing analysis when necessary and writing abnormality and accident reports; 7. Power Department; 8. Equipment defects and malfunctions analysis and measures; 9. Independent Engineering Safety Group; 10. Analysis, evaluation, and handling by categories; 11. Operations Commission QOC; 12. Scheduled or interim meetings to examine and propose views on prevention and improvement measures; 13. Feedback of views; 14. Safety Commission QSC; 15.Examination of important abnormalities, proposal of measures, and feedback to QDC; 16. Qinshan Plant leadership; 17. Examination and approval of information from higher-level nuclear safety departments; 18. Feedback of views; 19. National Nuclear Safety Administration and Shanghai Supervision Station; 20. Evaluation and supervision, feedback to the Independent Safety Engineering Group

Basic Principle Simulator for Qinshan Nuclear Power Plant

936B0040A Beijing HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 13, No 6, 10 Dec 92 pp 1-6

[Article by Zhu Yulong [2612 3768 7893] of the Nuclear Power Operation Institute, Wuhan: "Principles Simulator for Qinshan Nuclear Power Plant"; manuscript received 28 March 1992]

[Text] Abstract: This article describes the scope of simulation, functions, and hardware and software configurations of a principles simulator used for training purposes for the Qinshan Nuclear Power Plant 300MW generators. This simulator can demonstrate the basic principles of the nuclear power plant and its systems, and it can carry out normal operations under normal operating conditions and simulate 20 types of malfunctions and over 200 breakdown points. The simulator has excellent instructor control functions and abundant graphics, curve display, and other capabilities. It is the first nuclear power plant principles simulator designed and developed by China itself and was turned over for use in early 1991.

Key terms: Qinshan Nuclear Power Plant, principles simulator, simulation scope, hardware configuration, software configuration.

I. Overview

The simulation system used in the Qinshan Nuclear Power Plant principles simulator is based on the physical properties in power plant processes and can reflect the physical and thermohydraulic characteristics of each piece of equipment and system in the core. It also has graphics, curves, and instrument displays as well as light and sound alarm signals, and thus is capable of providing profound images that illustrate the basic principles of the nuclear power plant and its systems. This simulator used the Qinshan 300MW Nuclear Power Plant as a reference power plant and the data and equipment code names it uses are identical to the actual power plant. The operating personnel console screens have equipment for completing basic operations in normal operation and it can be configured with faults to aid in improving the analytical, diagnostic, and handling capabilities of operating personnel for malfunctions and accidents. This simulator is the primary and essential supplementary training tool that corresponds to full-range simulator training for nuclear power plant operating personnel. It can also be used for elementary training of other technical personnel and administrative personnel at nuclear power plants, and is an excellent study site for students in reactor engineering specializations in institutions of higher education.

The computers and real-time interface systems used in this simulator were imported from the United States, and China provided the funds for development, manufacturing the control console screens, and debugging the entire simulator. It is the first nuclear power plant principles simulator designed and developed by China itself and was placed into use in early 1991.

II. Simulation Scope

A. Reactor physics

The control rods are divided into six groups: A1, A2, T1, T2, T3, and T4. Factors affecting reactivity such as the core boron concentration, moderator temperature and density, fuel temperature and burnup, xenon poisoning, and so on can all be simulated. Based on the reactivity and other factors, neutron dynamics equations can be used to compute the average power, to compute the decay heat based on operating history, and so on, and to compute the axial power distribution and displacement and simulate xenon oscillations.

B. Primary loop system

This takes into consideration heat transfer in the reactor from the fuel elements to the coolant and the thermohydraulic characteristics of the piping, main pumps, and so on. It is divided into two loops with two main pumps, and displays are provided for the loop coolant flow rates, inlet and outlet temperatures, average temperature, and core boron concentration. In the area of the pressure safety system, it simulates the pressure stabilizers, spray valves, electric heaters, pressure release valves, pressure isolation valves, safety valves, and pressure release tanks, and provides displays of pressure stabilizer pressures, temperatures, water levels, and boron concentrations. It simulates the heat transfer process between the first and second sides of the steam generators and takes into account the impact of steam load and feedwater flow rates on water levels and pressures. In the area of the chemical volume system, it simulates the downward drainage loop, supplementary feedwater system, boronization system, upper filling loop, volume control tanks, and so on. In the area of the residual heat removal system, it simulates the two residual heat removal pumps, two heat exchangers, and the associated cooling systems, valves, etc., and thus can perform controllable regulation of complete shutdown reactor residual heat removal, temperature raising and pressure raising, low pressure, downward drainage, low pressure safety injection, and other functions. In the area of the safety injection system, it simulates four high-pressure safety injection pumps, two safety injection tanks, and the fuel replacement water tanks and related valves, and thus can perform high-pressure safety injection, low-pressure safety injection, and safety injection tank safety injection functions.

C. Secondary loop system

In the area of the main steam system, it simulates two main steam pipelines, four main steam bypass discharge valves, eight safety valves, two atmospheric release valves, two rapid-closing isolation valves, two rapid-closing isolation bypass valves, and the main steam connection motherpipe. For the steam turbine generators, it simulates the high-pressure tank, two steam/water separation reheaters, two low-pressure tanks, two steam condensers, and the steam turbine steam extraction system. In the area of the

condensed water feedwater system, it simulates the condensed water pumps, condensed water pressure raising pumps, air extraction pumps, high-pressure and low-pressure feedwater reheaters, oxygen removers, three main feedwater pumps, two main feedwater regulation valves, two main feedwater bypass regulation valves, and so on. It provides simplified simulation of the auxiliary feedwater system, steam turbine control and protection, generator excitation and grid connection, and so on.

D. Reactor control and protection system

For the nuclear measurement system, it simulates the source region and intermediate region measurement ranges and schedules, as well as the power region measurement range, axial power deviation alarms, and so on. It provides detailed simulation of the reactor power regulation system and can automatically regulate the reactor power based on the average temperature and reference to average temperature deviations as well as reactor power and load power deviations. In the area of the rod control system, it simulates the relative rod position indications and absolute rod position indications for six groups of control rods, and it is configured with a group selection switch for automatic and manual selective switching of a single group, control rod manually operated switches, and so on. In the area of the protection system, it mainly simulates the safe reactor shutdown system as well as a large portion of the dedicated safety facility protection system.

E. Thermodynamic measurement and control system

In the area of thermodynamic measurement, it simulates the transducers and associated instruments. The primary loop main control system mainly includes the main pump control and pressure stabilizer control systems, pressure stabilizer liquid level control system, pressure release tank pressure control, and so on. The chemical volume system control includes the supplementary water system, volume control tank liquid level control, downward draining back-pressure control, and so on. There is also control of all of the pumps and valves in the residual heat removal system and safety injection system. The secondary loop control mainly includes the main steam bypass discharge control, atmospheric pressure release discharge system control, and main and auxiliary feedwater pump control. In particular, it is capable of relatively detailed simulation of main feedwater main and bypass regulation valve cut-out and regulation characteristics.

III. Simulator Operation Capabilities

A. Stable operation capabilities

The simulator can simulate operation of an actual power plant from cold reactor shutdown → hot reactor shutdown → hot reserve → 15 percent of rated power → 100 percent of rated power and from 100 percent of rated power → 15 percent of rated power → hot reserve → hot reactor shutdown → cold reactor shutdown. The normal operating rules system for the simulator is based on the corresponding rules formulated for an actual power plant. Full-process operation is used for examination and confirmation of the functions and performance of all simulated systems. When the simulator is in stable operation, the actual measurement error of the primary parameters that affect the thermal equilibrium compared to the reference power plant design values is within +/- 1 percent. At 100 percent of rated power, when the simulator has been operating for 1 hour, its primary data are also stabilized within a +/- 1 percent error range. Both of these items attain the +/- 2 percent requirement stipulated in the United States ANSI/ANS-3.5,1985 "Nuclear Power Plant Operating Personnel Training Simulator Standards".

B. Malfunction simulation capabilities

The simulator can simulate 20 types of malfunctions and several breakdown points for each type of malfunction, with a total of more than 200 breakdown points. The 20 malfunction categories that can be simulated are: 1) Accidents involving uncontrollable lifting of the control rods; 2) Accidents involving seizure or slippage of the control rods; 3) Pressure stabilizer spray valve malfunctions; 4) Malfunction and opening of the pressure stabilizer pressure release valves; 5) During initial startup in its lifespan, a malfunction in the volume control tank supplementary feedwater system causing a boron dilution accident; 6) Malfunction of the chemical volume system back-pressure control valves; 7) Malfunction of the chemical volume system's upper filling flow rate regulation valves; 8) Malfunction of the volume control tank liquid level control; 9) Shedding 100 percent of the external load to the plant-used power; 10) Steam generator pressure sender malfunction; 11) Steam generator steam flow rate sender malfunction; 12) Steam generator feedwater flow rate sender malfunction; 13) Loop cold end temperature sender malfunction; 14) Loop hot end temperature sender malfunction; 15) Steam turbine impulse level pressure sender malfunction; 16) Main feedwater pump tripping; 17) Main steam isolation valve malfunction and closing; 18) Steam generator U-shaped piping ruptures; 19) Small loss of coolant in the primary loop; 20) Rupture in the main steam piping.

Testing of the above malfunction conditions shows that their transient variation trends are consistent with the design analysis.

C. Real-time operation capabilities

The simulator's simulation schedule is 250 ms. When operating at 100 percent of rated power, there is a substantial margin in the actual CPU time used, indicating the degree of optimization of the simulator's simulation procedures and management and dispatching procedures, and providing a margin for future revision and expansion.

IV. Instructor Control and Graphics Functions

The primary instructor control and graphics functions are:

1. Operating personnel control console screen diagnosis;

2. Initial conditions selection;

3. Operating personnel control console screen switch and potentiometer state checking;

4. Real-time, slow, and rapid selection;

5. Freezing function;

6. Re-release and re-operation;

7. Malfunction configuration function;

8. Local and auxiliary operation;

9. Operating parameter display and revision;

10. Printing function;

11. Plotting function;

12. Graphics and curves display function.

V. Hardware Configuration

Figure 1 is the hardware configuration diagram, including the computer systems, real-time interfaces, and operating personnel control console.

A. Computer systems

The main computer is a SELPAC 6741D minicomputer from the Encore Corporation in the United States. Its bus has a single-board CMOS CPU (containing a 32 kB cache), a floating-point processor FPC, 2 boards of ISM 4MB internal memory, a Winchester disk controller HSDP containing two 500MB Winchester disks, a magnetic tape controller BTP and tape machine, input/output controller IOP, and ADI interface board. The

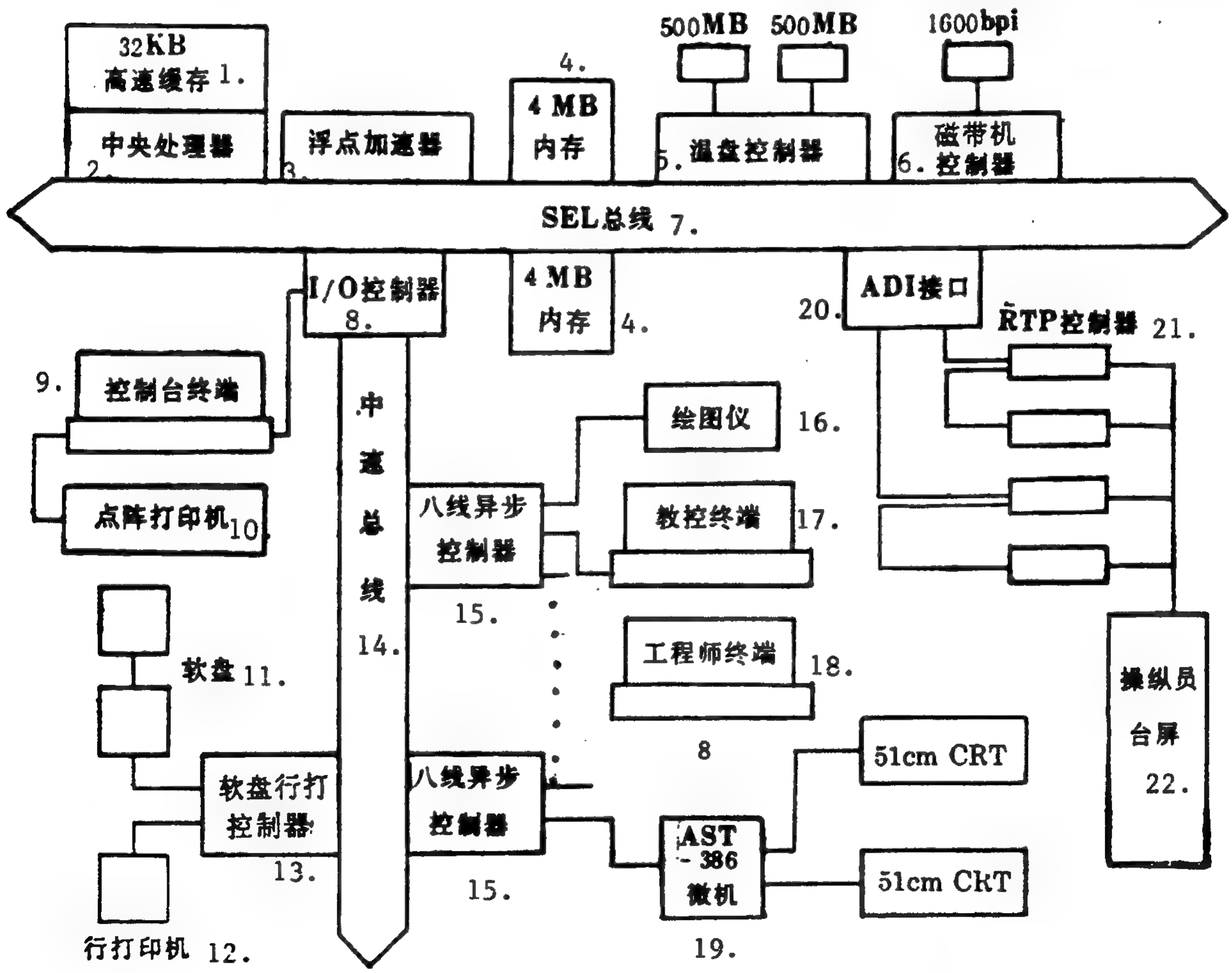

Figure 1. Hardware Configuration

Key: 1. 32 kB cache; 2. Central processor; 3. Floating point accelerator; 4. 4MB internal memory; 5. Winchester disk controller; 6. Tape machine controller; 7. SEL bus; 8. I/O controller; 9. Control console terminal; 10. Dot matrix printer; 11. Floppy disks; 12. Parallel printer; 13. Floppy disk and parallel printer controller; 14. Medium-speed bus; 15. Eight-line asynchronous controller; 16. Plotter; 17. Instructor control terminal; 18. Engineer terminal; 19. AST-386 microcomputer; 20. ADI controller; 21. RTP controller; 22. Operating personnel console screens

IOP is connected to the control console terminal, the dot matrix printer MP, and the medium-speed bus MP BUS. The MP BUS is connected to the parallel printer LP, floppy disk controller FL, and two eight-line asynchronous controllers 8LAS MUX. The RS-232 interfaces of the eight-line asynchronous controllers are connected to the plotter, instructor control terminal INS, eight engineer terminals ENG, and an AST-386 microcomputer. The engineer terminals are used for development and debugging. The AST-386 microcomputer has two 51 cm CRTs connected through the graphics board that are used for graphics and curves display. The ADI interface board is connected to the RTP controller, and the RTP is then connected to the control console screens.

B. Real-time interface

BUS0 and BUS1 on the ADI board are connected to the controllers in the real-time interface cabinet and each of the controllers is connected in a daisy-chain arrangement with 224 internal DO interface points and are used for the indicator lights and alarm lighted character panels. The AO has 104 channels used for the indicator instruments. The AI has 32 channels (eight in actual use) that are used to receive inputs from the potentiometers on the control console. The DI has 240 points that receive inputs from the switches and buttons on the console screens. The interface screens are configured with debugging boards that are used for off-line debugging.

C. Operating personnel control console screens

The console screens (OP in Figure 1) are connected via a real-time interface with the main computer and the operating personnel can carry out operations for all types of operating conditions at the power plant on the console screens. The console screens are divided into four parts. The first screen is located on the left side and is configured with the control equipment and indicator instruments for the secondary loop system. The second screen is located in the middle and is configured with control equipment and indicator instruments for the primary loop's main systems, pressure and safety systems, chemical volume control system, and nuclear measurement, reactor control, and protection. The third screen is located on the right side and is configured with control equipment and indicator instruments for the residual heat removal and safety injection systems, and it has two recorders. The fourth screen is located at the top of the other three screens and is used for configuration with the corresponding alarm lighted character panels and two color CRTs.

VI. Software Configuration

A. Computer system software

The computer plant supplied the MPX-32 operating system that utilizes a UTILITY program, ADI processing program, and FORTRAN 77$^+$ compiling program and SRTL scientific operations time database.

B. Applications programs

The applications programs have a total of 11 tasks. They are:

1. Simulator initialization tasks. They complete the console screen diagnosis, initial conditions selection, standard malfunction group selection, switch checking, and so on.

2. Real-time monitoring and control tasks. At fixed times, they restore the simulation tasks and graphics and data transmission tasks, and they perform operations recording read/write, simulation quantity numerical value input, etc.

3. Simulation tasks A. This includes reactor control, primary loop control, secondary loop control, reactor physics, chemical volume system, and residual heat removal and safety injection systems.

4. Simulation tasks B. This includes the thermodynamic primary loop processes, secondary loop processes, heat measurement, nuclear measurement, and reactor protection system.

5. Data recording and simulation quantity and numerical quantity output tasks.

6. Graphics and data transmission tasks.

7. Snapshot printing transfer and storage tasks.

8. Plotting tasks.

9. Instructor control order processing tasks.

10. Instructor control terminal fixed time display tasks.

11. Printing tasks.

The input and output sub-programs used in these tasks are written in assembly language and all the others are written in FORTRAN 77$^+$. Each of the tasks uses the sub-programs provided by the SRTL such as activation, erasure, self-linking, timer restoration, and so on to do the debugging and implements them in sequence according to preference. Global Common Data Region (GLOBAL COMMON) communications is used among tasks. The global common data region is established when the computer system is created and then all of the variable names that are used are written into the global common region data file. The related programs only have to use an "INCLUDE" statement to bring in the global common data file.

In addition, the program series related to graphics and curves displays are loaded into the AST-386 microcomputer and the main computer transmits the data to be displayed to the microcomputer at fixed times (at 250 ms intervals).

C. Debugging tools and other programs

We also established our own debugging tools for applications program development. They include program

compilation and linking, common region data dynamic display and revision, partial debugging and linked debugging methods, various measurement measures, and so on.

VII. Conclusion

This simulator is the first nuclear power plant principles simulator designed and developed by China itself, its development was successful, it attained international levels of similar products, and we trained personnel and accumulated significant experience during the research process.

Collection, Evaluation, and Feedback of NPP Operating Event Data

936B0040B Beijing HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 13, No 6, 10 Dec 92 pp 7-12

[Article by Fan Zhengping [5400 2973 1627] of the National Nuclear Safety Administration Suzhou Nuclear Safety Center: "Nuclear Power Plant Operating Event Data Collection, Evaluation, and Feedback"; draft manuscript received 9 March 1992, revised manuscript received 15 July 1992]

[Text] Abstract: During the operational period of nuclear power plants, implementation of a "Nuclear Power Plant Operating Unit Operating Event Reporting System" is used to collect data on operating events and to compile all relevant information regarding abnormal events that occur during the operational period of nuclear power plants into operating event reports based on the requirements in the "Reporting System". Then, screening and intensive analysis and assessment of operating event reports is done based on the corresponding screening standards and a detailed accident analysis report is compiled based on the stipulated content and format to facilitate the immediate discovery and handling of events that are portents of serious nuclear accidents. Finally, the results of these analyses and assessments are fed back to the relevant units or departments according to stipulated procedures and arrangements to enable all related personnel to gain a correct understanding of the essence and sources of the associated events and to enable broad dissemination and circulation of the experience and lessons, thereby continually raising safety levels at nuclear power plants while simultaneously improving economic results at nuclear power plants.

Key terms: nuclear power plant, operating event, data collection, analysis and assessment, information feedback.

I. Introduction

On a world scale, the technology for developing nuclear power is now basically mature. However, considerable effort is still required in the areas of improving nuclear power plant safety levels and operating quality. In various attempts to improve the safety performance of nuclear power plants, systematic collection, evaluation, and feedback of operating event data (operating experience) is an extremely effective measure. The operating events and experience and lessons at nuclear power plants in foreign countries show that whether they are serious accidents or regular events, the greatest majority are preceded by the occurrence a series of events that portend the problem. In this sense, if portent events could be immediately discovered and dealt with appropriately, the occurrence of serious accidents could be prevented and even avoided. Full collection and evaluation of nuclear power operating event data and feedback of the results of analysis and assessments to the relevant units or departments to help them derive lessons and improve their work has become a fundamental safety principle in nuclear standard work. For this reason, we must formulate the related system of regulations and use their conscientious implementation for immediate discovery of operating events related to safety, to do analysis and evaluation, and to formulate measures for their correction to enable a correct understanding of the essence and sources of the events, to enable widespread dissemination and circulation of the experience and lessons, and thereby continually improve nuclear power plant safety and economy.

Work to collect operating event data for nuclear power plants is mainly carried out through adherence to the nuclear power plant operating unit operating event reporting system. This reporting system has clear stipulations on the reporting standards, reporting procedures, and the report content and format. This article will discuss this issue and introduce several basic requirements and methods used in implementing operating event report archives, inquiries, selection, analysis, and correction measures, information feedback, and so on.

II. Reporting Standards

The core issue in the operating event reporting system is stipulating the standards for event reports, i.e. stipulating what must be reported when a particular type of operating event occurs. The National Nuclear Safety Administration makes clear stipulations based on China's concrete conditions in HAF0502-1-1, the "Nuclear Power Plant Operating Unit Operating Event Reporting System" and this will not be discussed further here.

III. Reporting Procedures

The reporting procedures should guarantee that information about operating events that occur is immediately transmitted to the relevant administrative departments and that there is sufficient time prior to submitting written operating event reports to do analysis and evaluation and determine the corresponding corrective measures for the associated event. Usually, when an operating event that affects the safety of a nuclear power plant occurs, the administrative unit should immediately report it. It is stipulated in HAF0502-1-1 that the operating unit should give an oral notification to the National

Nuclear Safety Administration within 24 hours after the event occurs. The mode of the oral notification can be by telegram, telephone, or a face-to-face report. Then, within 3 days after the event occurs, a written event notification must be submitted according to the stipulated formate. Finally, within 30 days after the event occurs, a detailed operating event report must be submitted according to the stipulated format.

In addition, in the situations below the operating unit is also required to supplement a supplementary report in correspondence with the operating event report.

1. In a situation in which the original event report requires supplementation or revision, a corresponding supplementary report should be submitted. For example, when the original event report is submitted, the overall event may not yet have concluded or the reasons for the equipment malfunction may not yet have been determined; or, after submitting it, it may be discovered that certain parts of the content of the original event report did not conform to the facts that were determined after an investigation of the event, or some important details may have been left out; or, there may have been no decision at the time regarding whether or not correction measures should be adopted, or decisions already made should be changed, or other situations in which a supplementary report should be submitted.

2. For complex events, if the National Nuclear Safety Administration feels that the original event report does not contain enough detail, the operating unit should submit a supplementary report based on the specified scope and content.

IV. Content and Format of the Reports

When deciding upon what content the operating event report should include, two factors must be taken into consideration:

1. Safety supervision at nuclear power plants: data on operating events should satisfy the requirements of nuclear generator safety performance inspections and operational safety analysis work.

2. Operating experience feedback: use operating event data for systematic analysis, evaluation, and information feedback for continual improvement of the design, construction, and operating technology levels of nuclear power generators.

The content that should be contained in operating event reports as stipulated in HAF0502-1-1 is:

A. General information

Name of the nuclear power plant and generator serial numbers, event report numbers, event names, initial event, times when the event occurred and concluded, date of the report and the person making the report, reporting standards, generator states and power levels prior to the event occurring, impact of the event on generator operation, power levels after the event, and radioactivity results.

B. Safety assessments

These are the analytical conclusions for the event and include the impact of the event on safety, latent hazards, and the nature of the event. They provide an overall explanation of the basis for the event, the nature of the system or equipment malfunctions in the event, and the availability of safety systems. They also analyze the outcome of similar events under other rationally believable conditions.

C. Report outline

Detailed language must be used to describe the overall nature of the event, including all sub-events included in the event, all system and equipment malfunctions during the event, human error, responses of personnel on duty, the causes of each sub-event (including the basic causes and direct causes), the outcomes, methods, experiences, and lessons discovered, corrective measures, ultimate outcome, and so on. The writing must be concise without leaving out important details.

D. Main body of the report

The main body of the report is the primary content of the event report, and it should provide a clear and accurate description of all processes and phenomena by levels that were involved in the event. This is particularly true for the process of the event occurring and developing. The equipment and personnel situations and responses, what the people at the site saw and heard, and everything they did should be recorded in an effort to provide more information to the personnel analyzing the event. The contents that the main body of the report should include are: 1) Event background: generator states prior to the event occurring and the availability of the relevant safety systems. 2) The time that all of the sub-events involved in the event (system or equipment malfunctions and human error) and their evolutionary processes over time; the basic causes for each sub-event (system or equipment malfunctions, human error, procedural errors, etc.) and the direct factors that caused them to occur; the mode and mechanisms in which each event occurred and the effects on systems or equipment; the method by which each sub-event was discovered. 3) The names, models and manufacturing plants for the systems, equipment, parts, or components experiencing problems. 4) The relevant details concerning the other systems or equipment that were affected during the process of the event. 5) When an event prevents certain safety systems from functioning, the process and time from their discovery to the restoration of normalcy. 6) The redundancy conditions of systems and equipment experiencing problems and the availability of redundant systems and equipment during the event process. 7) All operations carried out during the event process; for operating errors of personnel at the site, it should be pointed out whether or not

they were diagnostic errors, violations of approved procedures or erroneous procedures, failures to explain the associated procedures, or mistakes caused by abnormal environmental conditions at the work site (such as high temperatures, noise, etc.); the categories of the personnel making mistakes. 8) The relevant details concerning safety systems and redundant systems or equipment that was automatically or manually placed into operation during the event process, including the startup reasons and number of instances, the results of placing them into operation in each instance, and so on. 9) The outcome resulting from the event, including the impact on power plant operation, radioactive outcomes, economic losses, etc. 10) Experience, lessons, and corrective measures, including the corrective measures already adopted or planned for adoption for each sub-event. A comprehensive introduction to and analysis of the views on handling the event, the emergency measures and short-term remedial measures proposed for adoption, and long-term measures for reducing the probability that similar events could occur. 11) Comparative analysis of similar events that occurred prior to the appearance of problems in systems or equipment and research on why the corrective measures adopted in previous events were unable to prevent the reoccurrence of the event. 12) Other questions and concise lists of reference information that require explanation.

The format of the event reports should be as concise and practical as possible and every effort should be made at normalization and standardization. After establishing a nuclear power plant operating event database, the specialized terminology used in the event reports should be consistent with the database to provide favorable conditions for entering data into the database and for analysis of subsequent operating events.

V. Archiving and Searching Operating Event Databases

Nuclear power plant operating event databases are an important foundation for nuclear safety supervision and operating experience feedback. The archival form of operating event reports should meet the requirements of frequent searches of operating event data involved in nuclear power plant safety supervision and operating experience feedback work. Based on needs, nuclear safety departments and operating units can analyze, evaluate, and summarize operating event data from nuclear power plants at fixed times or on a regular basis. In particular, there is a need for immediate understanding of safety problems that are common at the present time, repeated occurrences of similar events, trends and typical examples of events, the characteristics of common factor and human factor events, and the radioactive outcome that is created for the environment and personnel.

When the number of operating event reports grows to a significant number, computerized data management should be adopted to facilitate inquiries and applications, meaning the establishment of a corresponding nuclear power plant operating event database. The associated search software should also be installed in the database. Each operating event report has many entries for search purposes such as the name of the nuclear power plant and generator serial numbers, basic characteristic parameters of the reactor, event report numbers, event names, initial events that occurred, dates on which the events occurred, report standards, states of the generators when the events occurred, systems or equipments that experienced problems, the systems or equipment that were involved, the causes of the events and the manner in which they were discovered, the effects and outcomes of the events, corrective measures, key terms for searching entries, and so on. Before nuclear power plant operating event reports are included in the databases, the operating event assessment reports should be rewritten according the database requirements to convert narrative-type event descriptions into coded information that computers can accept to facilitate the use of computer capacity and the compilation of searching software.

The National Nuclear Safety Administration established the "AORS Abnormal Event Database" for nuclear power plants in 1989. It is a large database that uses the IM/DM database management system on a Cyber 180/830 computer system. Currently, with the exception of the entry of operating event data from nuclear power plants in foreign countries, which is somewhat greater in amount, preparations are now underway for continual entry of operating event data from China's nuclear power plants.

VI. Operating Event Data Selection and Evaluation

After the Three Mile Island event, the International Atomic Energy Agency proposed reinforcing safety supervision over nuclear power plant operation. One aspect was screening nuclear power plant operating event data and conducting intensive analysis and evaluation to enable the immediate discovery of the events that portend several serious nuclear accidents. Adopting immediate corrective measures for these events and feeding back the associated information to the relevant units and departments could prevent the occurrence of serious nuclear accidents and improve safety levels at all nuclear power plants.

The standards for screening operating events usually takes the following aspects into consideration:

1. Serious radioactive accidents, including the mode and amount of radioactive materials that are released outside of nuclear power plants and that violate state stipulations and subject the public to irradiation in excess of limits. Irradiation that seriously contaminates the work site, surrounding area, or work personnel in excess of limits.

2. Damage rates to core fuel elements that exceed limits.

3. Category 3 or 4 working conditions that appear in analyzed nuclear power safety analysis reports or events whose outcomes are equivalent to category 3 or 4 working conditions.

4. Working conditions not analyzed in nuclear power plant safety analysis reports that seriously affect safety.

5. Major defects or procedurals errors that occur in the safety systems and primary loop equipment or main piping that if not corrected might cause serious outcomes.

6. Two or more common factor breakdowns, a series of random breakdowns, or a lose of effectiveness of safety facilities in important safety systems during an event.

7. Two or more human errors or procedural errors occurring during one event.

8. Two or more similar events occurring in one-half year in the same nuclear power plant.

A detailed event analysis report is compiled based on the events screened using the eight standards outlined above and on a foundation of intensive analysis and evaluation. The content of the analysis and evaluation is:

1. Background of the event: an explanation of the state of the generators when the event occurred, the availability of the related safety systems, and design explanations and operating conditions of the systems or equipment in which the problems occurred.

2. Outcome of the event: analysis of the actual outcome resulting from an event, other possible routes that may cause associated events to occur, and the outcomes that could result from each route. Also, research on the outcomes that might arise from similar events that could occur in other rationally believable situations (for example, higher power levels).

3. Causes of the event: analysis of the fundamental causes of the event and the direct causes that led to its occurrence as well as problems that exist in systems, equipment, procedures, auxiliary facilities, and the man-machine interface area that caused or exacerbated an event.

4. Response of on-site personnel: intensive analysis of the responses of personnel at the site, the interaction between each operation carried out and the personnel, and so on.

5. Analogous analysis: analogous analysis is carried out for the causes, occurrence, and development processes of an event and its outcome with similar events that have occurred in the same generator, the same nuclear power plant, or other nuclear power plants to explore the interrelationships among them.

6. Corrective measures: a description of already adopted or formulated corrective measures, including on-site emergency measures that prevented further worsening of the event, short-term remedial measures, long-term measures to deal with the fundamental causes of the event and reduce the probability of similar events from re-occurring, and analysis of the reliability and the advantages and disadvantages of each of them. If this type of event has occurred previously, there should also be analysis of why the corrective measures adopted in the previous event failed to prevent it from re-occurring.

7. Experience and lessons: analysis and summarization of the experience and lessons that should be absorbed, including lessons that should be absorbed in design, construction, operation, quality assurance, safety analysis, personnel training, and other areas.

8. Conclusions and proposals: drawing conclusions regarding the essence or seriousness of an event, as well as offering proposals regarding the design of the systems or equipment involved in the event, future operational management, and other areas, including detailed introductions to the content of the proposals and implementation programs.

VII. Implementation of Corrective Measures

Nuclear safety departments should formulate examination and approval procedures for the importance and degree of technical complexity for safety concerning the corrective measures adopted after the occurrence of an operating event. There should also be the corresponding emergency response examination and approval procedures for the emergency response measures that must be adopted during the process of an event or after an event. The corrective measures that are formulated should be acceptable to the unit with responsibility for their implementation. Usually, several implementation programs available for selection should also be formulated. The operating unit should be responsible for organizing implementation of all of the corrective measures and nuclear safety departments should be responsible for supervision. The primary objectives of supervision are: 1) To verify that the corrective measures already approved are being implemented; 2) To verify that during the process of their implementation the corrective measures conform to stipulated or approved procedures; 3) To determine the results following implementation of the corrective measures.

VIII. Operating Event Information Feedback

To continually improve nuclear power plant design, construction, and operation technology levels, information on nuclear power plant operating events should be immediately fed back to the relevant departments and units. For development of the nuclear power construction industry and S&T progress in a particular country, operating event information from nuclear power plants also should be immediately reported to the relevant government departments, nuclear power companies, nuclear power equipment design units, companies with responsibility for nuclear power projects, nuclear power

equipment manufacturing plants, nuclear power scientific research organizations and technical colleges, and so on. Moreover, the content of the information and scope of notification that should be reported should be stipulated on the basis of different requirements in each area.

Nuclear power plant operating event data from foreign countries received through international information exchanges should also be handled via methods similar to those outlined above in regard to their requirements in the areas of archiving, searching, screening, evaluation, and feedback.

IX. Conclusion

The experience obtained in the process of operating nuclear power plants plays an important guiding role in their design, construction, operation, maintenance, quality assurance, and safety evaluation. After the Three Mile Island incident, safety supervision and operating experience feedback during the nuclear power plant operation stage has received attention in many more countries. Now, every nation that has developed nuclear power has used legal procedures to formulate an event reporting system and established the corresponding operating experience feedback system. This has now become an essential measure in nuclear safety supervision and evaluation work, and is also an effective way to develop nuclear power production and improve design, construction, and operation technology levels of nuclear facilities.

China's nuclear industry now has a development history covering 30-plus years and we have accumulated substantial experience. However, our nuclear safety supervision system and operational management systems are not yet sufficiently perfect and we have not summarized well the experience gained in the process of operating nuclear facilities. Thus, formulating various types of administrative regulation systems and perfecting a nuclear safety supervision and operating experience feedback system are urgent tasks in the development of our nuclear power industry.

Zhejiang To Build Another Nuclear Power Plant

93P60186 Beijing RENMIN RIBAO in Chinese 6 Mar 93 p 1

[Text] Zhejiang Province is going to build its second nuclear power plant.

Last year, Zhejiang Province invested 140 million yuan in electric power construction, adding 600,000 kilowatts in power generating capacity. This year, the province will invest 150 million yuan and add some 850,000 kilowatts in generating capacity.

At the end of last year, at the direction of the Ministry of Energy Resources, the State Council and over 140 nuclear power experts reviewed the Sanmen nuclear power plant feasibility study report. It was considered that Sanmen was indeed an ideal site for the construction of a nuclear power plant and it was decided to build a facility with a total installed capacity of 4000MW—two 1000MW pressurized-water reactor units to be installed in the first phase—at a cost of some 10 billion yuan. This will be the second big nuclear power plant in Zhejiang after the Qinshan plant.

Guangdong Selecting Sites for More Nuclear Power Plants

HK2502122093 Hong Kong ZHONGGUO TONGXUN SHE in Chinese 1237 GMT 18 Feb 93

[Text] Guangzhou, 18 Feb (ZHONGGUO TONGXUN SHE)—As the Daya Bay Nuclear Power Plant is entering its latter construction period, Guangdong will decide this year on the site of its second nuclear power plant and invite bids for it. In the meantime, Guangdong Province is also busy selecting sites for its third, fourth, fifth, and sixth nuclear power plants.

It has been learned that Guangdong Province will devote major efforts this year to the development of nuclear energy because of a lack of the necessary conditions for hydropower generating and a serious lack of coal. The province plans that electric power produced by nuclear power plants will account for a quarter of the total, therefore, in the next 10 years, Guangdong is ready to build several nuclear power plants.

In the middle of last year, Guangdong Province submitted a proposal to the central authorities on the construction of a second nuclear power plant; so far it has not been ratified.

An informed source disclosed that site selection for the third, fourth, fifth, and sixth nuclear power plants will start this year along with feasibility studies. Site selection for these power plants will mainly proceed in the eastern and western regions of Guangdong.

Removal of Actinide Elements From High-Level Radioactive Waste by Trialkyl Phosphine Oxide (TRPO) Extraction—The Stripping of Actinide Elements From Loaded TRPO Organic Phase

40100056A Beijing HE HUAXUE YU FANGSHE HUAXUE [JOURNAL OF NUCLEAR AND RADIOCHEMISTRY] in Chinese Vol 14 No 4, Nov 92 pp 193-201

[English abstract of article by Song Chongli, Xu Jingming, and Zhu Yongjun of the Institute of Nuclear Energy Technology, Tsinghua University, Beijing, 102201; MS received 26 Jun 91, revised 15 Apr 92]

[Text] The stripping behavior of actinide elements loaded in 30 percent TRPO-kerosene solution with nitric acid, oxalic acid and sodium carbonate solution is studied and stripping parameters are given. Americium and lanthanide elements can be effectively stripped with 5-6 mol/l nitric acid, but at higher nitric acid concentration third phase would appear. More than 99 percent

neptunium and plutonium could be recovered in two times stripping by 0.5 mol/l oxalic acid with crossflow. Uranium is stripped with sodium carbonate. The cross contamination between the three fractions is very little. A proposed flowsheet for the removal of actinide elements from high-level radioactive waste by TRPO extraction is presented.

Determination of Hydration Number of Uranyl Ion by ^{1}HNMR

40100056B Beijing HE HUAXUE YU FANGSHE HUAXUE [JOURNAL OF NUCLEAR AND RADIOCHEMISTRY] in Chinese Vol 14 No 4, Nov 92 pp 202-206

[English abstract of article by Yang Qun, Luo Wenzong, Dang Shuqin, and Wang Dexi of the China Institute of Atomic Energy, P.O. Box 275, Beijing, 102413; MS received 15 Apr 91, revised 29 Dec 91]

[Text] The hydration number of uranyl ion is determined by ^{1}HNMR at low temperature. In perchloric acid, the hydration number of uranyl ion varies from 4 to 5 with the increment of $C(H_2O)/C(UO^{2+}{}_2)$ mole ratio. In hydrochloric acid, the hydration number of uranyl ion decreases with the increment of $C_{HCl}/C(UO^{2+}{}_2)$ mole ratio. When $C_{HCl}/C(UO^{2+}{}_2) = 4.0$, uranyl ion is coordinated with no water molecule. In nitric acid, when $C(HNO_3)/C(UO^{2+}{}_2) \geq 2.0$, uranyl ion is coordinated with two water molecules and it is independent of the concentration of nitric acid. The probable structures of coordination compounds of U(VI) in solution are discussed.

Studies on U(IV) Nitrate as Reductant in U/Pu Separation of Purex Process

40100056C Beijing HE HUAXUE YU FANGSHE HUAXUE [JOURNAL OF NUCLEAR AND RADIOCHEMISTRY] in Chinese Vol 14 No 4, Nov 92 pp 207-214

[English abstract of article by Yu Enjiang, Liu Liming, et al. of the China Institute of Atomic Energy, P.O. Box 275, Beijing, 102413; MS received 23 Sep 91, revised 15 Apr 92]

[Text] The stability of U(IV) nitrate in separated organic solution (30 percent TBP) and system of two phases (organic and aqueous) is studied. The results show that the oxidation of U(IV) in TBP phase is completed in about 5-7 hours. The concentration of HNO_2 in the TBP phase gradually increases during the oxidation of U(IV). The losses of U(IV) are about 10-20 percent during cascade experiment containing uranium and nitric acid.

The effects of some factors such as concentration of Pu(IV) and U(IV) in the TBP phase, concentration of HNO_2 and N_2H_4 in aqueous phase, and U(IV)/Pu (molar ratio) on back-extraction of Pu(IV) are investigated.

Through cascade experiment with simulated 1BF feed, the effects of some factors such as U(IV)/Pu (molar ratio), feeding point of U(IV) feed, the acidity of aqueous phase, the o/a phase ratios in the reduction zone on the separation of U/Pu are investigated. The results show that when U(IV)/Pu (molar ratio) is 8, 5, 3 and 2, the *DF* for removal of Pu from U product is always greater than or equal to 1.36×10^4.

Study on Extraction of Uranium (VI) by Bis(4-Acylpyrazol-5-One) Derivatives With Lower Polymethylene

40100056D Beijing HE HUAXUE YU FANGSHE HUAXUE [JOURNAL OF NUCLEAR AND RADIOCHEMISTRY] in Chinese Vol 14 No 4, Nov 92 pp 215-219

[English abstract of article by Chen Yude, Shi Xianfa, and Mao Jiajun of the Department of Chemistry, Tongji University, Shanghai, 200092, Du Huifang, Wang Yu, and Fu Lei of the Department of Nuclear Science, Fudan University, Shanghai, 200433; MS received 19 Aug 91, revised 29 Dec 91]

[Text] A family of bis(4-acylpyrazol-5-one) derivatives in which two 1-phenyl-3-methyl-4-acylpyrazol-5-one subunits are linked by a polymethylene chain—$(CH_2)_n$—of lower length (n - 2,3,4,6) have been designed. The extraction reaction and their equilibrium constants have been found. The mechanism of extraction is discussed.

Synergistic Extraction of Uranium (VI) With 1,10-Bis(1'-Phenyl-3'-Methyl-5'-Oxopyrazole-4'-yl) Decanedione-1,10 and 1,10-Phenanthroline

40100056E Beijing HE HUAXUE YU FANGSHE HUAXUE [JOURNAL OF NUCLEAR AND RADIOCHEMISTRY] in Chinese Vol 14 No 4, Nov 92 pp 220-225

[English abstract of article by Liu Jianmin, Yang Rudong, and Pi Xiangdong of the Department of Chemistry, Lanzhou University, Lanzhou, 730000; MS received 19 Jul 91, revised 7 Jan 92]

[Text] Synergistic extraction of $UO^{2+}{}_2$ with 1,10-bis(1'-phenyl-3'-methyl-5'-oxopyrazole-4'-yl) decanedione-1,10 and 1,10-phenanthroline has been investigated. The composition of the extractive and equilibrium constant of the synergistic extraction have been determined. The solubility, molar conductance, thermal stability, UV, IR, and ^{1}HNMR spectra of the solid extractive are discussed. The synergistic extraction mechanism and the possible structure of the complex have been suggested.

Solvent Extraction of Uranium (VI), Thorium (IV) With Petroleum Sulfoxides (PSO)

40100056F Beijing HE HUAXUE YU FANGSHE HUAXUE [JOURNAL OF NUCLEAR AND RADIOCHEMISTRY] in Chinese Vol 14 No 4, Nov 92 pp 226-231

[English abstract of article by Wang Jinhua and Zhou Zuming of the Department of Nuclear Science, Fudan University, Shanghai, 200433, Xu Dimin, Chen Yude, and Mao Jiajun of the Department of Chemistry, Tongji University, Shanghai, 200092; MS received 28 Oct 91, revised 12 Apr 92]

[Text] The influence of the temperature, as well as the concentrations of nitric acid, petroleum sulfoxides (PSO), salting-out agent and metal ions on the distribution ratio of uranium (VI), thorium (IV) has been systematically studied. It is found that the extraction regularity of PSO is similar to that of DOSO and TBP. Both uranium (VI) and thorium (IV) exhibit the maximum distribution ratios at 5-6 mol/l HNO_3 and 3-4 mol/l HNO_3, respectively. The extracted compounds are determined to be $UO_2(NO_3)_2$ x 2PSO and $Th(NO_3)_4$ x 3PSO, respectively. The distribution ratios of uranium (VI) and thorium (IV) increase rapidly in the presence of salting-out agent. The extraction enthalpies of uranium (VI) and thorium (IV) with PSO are $\Delta H_U = -26$ kJ/mol and $\Delta H_{Th} = -29$ kJ/mol.

Destructive Determination of Burnup of Tested Fuel Element of Qinshan Nuclear Power Plant by γ Spectrometry

40100056G Beijing HE HUAXUE YU FANGSHE HUAXUE [JOURNAL OF NUCLEAR AND RADIOCHEMISTRY] in Chinese Vol 14 No 4, Nov 92 pp 246-252

[English abstract of article by Yang Liucheng, Zhu Rongbao, et al. of the China Institute of Atomic Energy, P.O. Box 275, Beijing, 102413]

[Text] The basic concept and method for burnup determination of irradiated reactor fuel element by computer-based Ge(Li) γ ray spectrometer are described for tested fuel elements from Qinshan power plant. Experimental results of seven cutting positions and the average burnup value of one rod are given. Dead-time correction, spectrum data reduction, irradiation history correction and sample preparation are presented.

Shanghai To Play Pivotal Role in Wind Power Development

9360041A Beijing ZHONGGUO NENGYUAN [ENERGY OF CHINA] in Chinese No 12, 25 Dec 92 pp 44-45

[Article by Zhu Chengming [2612 2052 0682], Shanghai Solar Energy Society, Special Committee on Wind Power]]

[Text]

Advantages and Goals for the Development of Wind Power at Shanghai

1.Development of Wind Power at Shanghai

In the early 1970s Shanghai first used decommissioned "Zhi-5" [helicopter] blades to successfully test manufacture an 18kW wind power generator 16 meters in diameter, which was the largest in the country at that time. It was operated on Shengsi Island, Zhejiang, for 9 years. Later, in 1990, four improved 22kW units, rated for winds up to 8.5 meters per second, were operated and joined the grid on the island. In December 1989, a Chinese-designed and built 55kW wind-powered electric generator passed technical approval. Most of the blades for a 200kW wind-powered electric generator that was installed on Pingtan island, Fujian, and for Chinese-made 100-Watt, 500-W, 1kW, 3kW, and 20kW wind-power generators were all test-manufactured and put to full use by the Shanghai Fiberglass Institute. In early 1980, the Shanghai Underwater Facilities Factory, and Shanghai Navigation Marker Factory successfully manufactured a series of 50-Watt, 100-Watt, and 150-Watt wind-powered navigation lights, and earned technical achievement awards from the Ministry of Transportation. Most recently, the Shanghai Underwater Facilities Factory again successfully built 1kW wind power generators, one of which was installed on a navigation light structure in May 1990 and was routinely used on Shanbanzhou at the mouth of the Zhu Jiang in Guangdong, and another one was recommended by the Solar Power Society for shipment to the University of Hawaii Natural Energy Institute to be used in a wind-solar combined-use project where it earned unanimous praise from foreign and domestic quarters. The Shanghai Fishing Machinery Institute successfully built a wind-powered oxygen generator for breeding purposes that passed technical approval; teams from the Shanghai Mechanics Academy, Shanghai Electric Cable Coil Factory, Shanghai Railroad Academy, and Shanghai Electric Machinery Factory have each done a lot of work and made good progress in test-manufacture, assembly, and theoretical aspects of wind-powered machinery; and Shanghai also has excellent advantages in developing electrical machinery and storage batteries that use wind-powered machinery. Further, the Shanghai Fiberglass Institute imported U.S. pressure-molded fiberglass blades for wind-power equipment, successfully produced them for the first time in China, and began to produce them. They have a high blade strength and rigidity, ideal for electric energy, and the have a high luster that is better than anything hand made, are of uniform quality, don't need to be weighted, and are inexpensive.

2. The Natural Environment of Shanghai

In the Shanghai area, along the east coast, the East China Sea, and lands bounding the mouth of the Chang Jiang, the coastline is long and the land flat; and the northwest winds in autumn and winter, and southeast winds in spring and summer provide abundant wind power resources. Shanghai Weather Bureau statistics on coastal and marine winds of over 3.4 meters per second, average effective wind-energy density, and cumulative hours of wind power are shown on the chart:

	Yushan	Yinshui-chuan	Shengsi	Lusi	Zhapu	Chong-ming	Baoshan	Nanhui	Fengxian	Jinshan
Effective average wind-energy density (Watts/sq meter)	727.7	430.2	459.4	378.1	113.3	127.0	91.3	102.7	103.5	101.8
Cumulative hours per year of wind speeds over 3.4 meters per second	7875	7111	7083	7232	3549	4017	4276	3558	3613	3301
Cumulative hours per year of wind speeds over 5.5 meters per second	6519	5126	5134	5047	1301	1820	1158	1108	1222	1036
Percentage of effective wind power per year	90	81	81	83	41	40	40	41	41	38

On the chart, wind-energy is greatest at Yushan, which has an average effective wind-energy density of up to 728 Watts per square meter, more than 7 times greater than the wind-energy of the coastal areas, and it has effective wind power for 90 percent of the year. Its cumulative hours of wind speeds $\geq$ 3.4 meters per second for one year is 7,875 hours, and for wind speeds $\geq$ 5.5 meters per second it is 6,519 hours. At Yushan, the average effective wind-energy density varied from 533.7 to 899.8 Watts per square meter, with the highest values occurring in December and February (899.8 Watts per square meter and 853.7 Watts per square meter). The lowest wind-energy density occurs in the late spring and early summer, May and June, with June being the lowest (533.7 Watts per square meter), only 60 percent of that for December.

Shanghai does not produce coal or oil, and the imbalance of supply and demand is especially acute. A planned and measured development of the wind power industry, actively pursued, is one way of applying the energy policy of " Suiting measures to local conditions, overage sharing, comprehensive use, and attention to profits" to this situation.

3. Shanghai Wind Power Development Goals

(1) Organize the research and production technology for a line of 100- to 1,000-Watt small-scale wind power equipment, which are already available, and put them into the competitive market.

There is a great demand now for 100- to 1,000-Watt wind-power products, and they have wide applicability. Shanghai has the foundation and capability for setting up full-scale product lines for wind-power equipment, electrical machinery, blades, and storage batteries to meet the needs of both domestic and foreign consumers.

(2) Actively create the conditions for initial research manufacturing of 5,000 Watt, 20kW, 50kW, and 100kW wind-powered machinery, and advertise them widely.

Advertise the use of wind power at Yushan, Shengsi, Lsi, Zhapu, and Chongming test sites and set up [other] wind power farms. Go after the countries along the coast of South East Asia and Africa to set up conditions for exporting wind-powered machinery, offer the technology, and take over the market.

(3) Make use of the technical advantages of Shanghai's special schools and academies to explore the theoretical and research aspects of wind-powered machinery.

Shanghai has the conditions and capability to undertake domestic research manufacturing of large-scale wind-power machinery, such as the Shanghai Fiberglass Institute which already has over 20 years of practical experience in the research manufacturing and production of wind-power blades, and has made a great contribution to the country in this field. Pertinent State organizations have designated in the Eighth 5-Year Plan that Shanghai be the center for development of large-scale wind-power blades, and they are looking to Shanghai for support and cooperation in making further contributions.